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THE

AMERICAN TEXT-BOOK

OF

OPERATIVE DENTISTRY.

IN CONTRIBUTIONS BY EMINENT AUTHORITIES.

EDITED BY

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THIS BOOK IS DEDICATED TO

JAMES TRUMAN, D. D. S., L.L. D.,

THE CHARACTERISTIC OF WHOSE LONG PROFESSIONAL CAREER HAS
BEEN THE INCULCATION OF THE PRINCIPLES UPON
WHICH THE WORK IS BASED.

PREFACE

The demand for a new edition of the *American Text-book of Operative Dentistry* has necessitated much more than a mere revision of the previous text. The work has been largely rewritten, and the fourth edition is therefore practically a new book. Such a radical change has been rendered necessary by the rapid evolution which has taken place throughout the entire domain of the science and art of dentistry since the publication of the previous edition. The accumulation of new data, the investigation of the deeper problems of dental science, and the modification exerted by these factors upon the practice of dentistry have wrought changes that in certain departments are little less than revolutionary. So rapid and far-reaching in their effects are many of the changes which have taken place that the whole subject of operative dentistry has been and still is in a state of flux.

The mirroring of the progressive movement in operative dentistry will be evident in the plan as well as in the text of this work. The subject of cavity preparation is treated as a technic procedure, first, because it can be most intelligently comprehended as such, and further, because the work is primarily intended for the instruction of the undergraduate student. It is fully recognized that the scientific basis of such subjects as pyorrhea alveolaris, tooth discoloration, tooth extraction, root-canal treatment, orthodontia, etc., is much more fully elaborated in the present work than would be justifiable in a treatise or text-book devoted exclusively to operative dentistry as an art; but as there still appears to be a demand upon the part of students for a volume furnishing a comprehensive view of the fundamental principles upon which alone an intelligent and rational practice may be based, the treatment of the subject of operative dentistry in the present work has been extended to include those principles.

Certain differences of opinion will be occasionally manifest in the work in the treatment of allied subjects by different authors. While such differences are, of course, not desirable in a work intended for the use of untrained students, and while no conflict of opinion will be noticed with respect to established scientific principles, it is manifestly impossible to secure unanimity upon subjects which have not as yet

reached a stage of development entitling them to classification among the exact sciences. For example, the unsettled question whether under any circumstances extraction is a justifiable operation in connection with the correction of malocclusion, has led to differences of opinion that are not at present reconcilable, and cannot be until a larger body of evidence based upon observation and experience has been submitted at the bar of professional judgment.

The Editor takes this occasion to express his deep sense of appreciation of the uniform courtesy and spirit of helpfulness which have characterized the attitude of all of his collaborators in this work, for their patience under his suggestions, and their willingness to sacrifice personal interests to the thoroughness and accuracy of the work as a whole. To the publishers his thanks are due for their unhesitating coöperation in every effort which tended to the completeness of the work in all its phases, and he is likewise under obligation to his colleague, Dr. Riethmüller, for the preparation of the accurate and copious index.

The Editor assumes personal responsibility for the nomenclature used throughout, and in submitting the volume to the critical consideration of his fellow-teachers and his larger circle of fellow-students he can hope for it no more generous treatment, nor, indeed, could he expect more, than has been so freely accorded to its predecessors.

E. C. K.

University of Pennsylvania, 1911.

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INTRODUCTORY.

A STUDY of the advances which have of recent years taken place in the field of Operative Dentistry will reveal, besides the important additions to our knowledge in the shape of novel methods and improved technique, a vastly more important advance manifested in a better and more general understanding of scientific principles, and the application of dental science to dental art, resulting in a more rational practice. Especially is this true in regard to the etiology of dental and oral pathological conditions, and the *rationale* of the modes of treatment indicated for the morbid states constantly confronting the dental practitioner.

The modifications in surgical methods and the greatly improved results which are the outgrowth of modern scientific studies in bacterial pathology, while they have made a considerable impress upon dental operative methods, have not, however, received that universal practical acceptance among dental operators which their immense importance demands. There is no field of special surgery in which the importance of exact knowledge with respect to aseptic and antiseptic treatment is more marked than in the practice of dentistry. The dental operator is continually confronted with septic conditions, so that precise knowledge of their origin, causes, phenomena, and treatment are essentials to the legitimate practice of the profession.

The performance of any operation, and especially those which are classified as capital, with unclean hands or infected instruments would in the present stage of surgical art be regarded as criminal malpractice. It should be so considered in dentistry. The loss of a patient's life as the result of surgical septic infection is no longer permissible. Lack of antiseptic precautions in certain dental operations may directly lead to and as a matter of fact has been the cause of fatal results. It has been shown conclusively[1] that a large variety of pathogenic microorganisms are almost constant inhabitants of the oral cavity. In addition to the numerous forms which bring about an acid reaction, there are many specific organisms which produce in inoculated animals pyemia and septicemia in their several clinical classes. But while the dental practitioner is not often called upon to face the issues of life

[1] W. D. Miller, *Dental Cosmos*, November, 1891.

and death in the course of his work, his responsibilities as related to the issues with which he does deal demand of him the same care and thoroughness in order to attain the character of result which the possibilities of modern dentistry require of him. In the following pages the importance of asepsis and antisepsis in dental operations is constantly impressed upon the mind of the student.

By the term *asepsis* is specifically meant the condition under which are excluded those influences or causes which induce infection by pathogenic micro-organisms; when a tissue or surface has been rendered germ-free it is said to be in an *aseptic* condition. By *antisepsis* is meant the means by which the septic state is combated or the aseptic state is attained.

Under the aseptic condition repair of tissues takes place normally without interference, wounds and injuries heal with a minimum of disturbance, and the inflammatory concomitant is of the simple traumatic type, without suppuration or tendency to diffusion.

The aseptic state, in many operations in the mouth, is not readily attainable and cannot be maintained for any length of time; but in all operations which involve the pulp and pulp chamber, as well as the periapical region through the pulp canals of teeth, strict aseptic conditions, as regards external infection, are perfectly attainable through exclusion of the oral secretions by means of rubber dam, the use of suitable disinfectants, and sterilized instruments. It is the class of operations here alluded to which are most prolific of disturbance from infective inflammations caused by ignorant or careless manipulation.

The time is at hand, if indeed it has not already arrived, when purulent inflammations following dental treatment will be regarded with the same condemnation by the dentist as by the general surgeon. The operative section of this work is written in full recognition of the principles here indicated.

OPERATIVE DENTISTRY

CHAPTER I

HUMAN ODONTOGRAPHY

By ALTON HOWARD THOMPSON, D.D.S.

The teeth are located at the portal of the alimentary system of the animal organism. They help to differentiate in the choice of the elements of nutrition and reduce these elements to digestible condition. The dental armament is, therefore, the first and chief factor in the mechanism of alimentation. The teeth are, morphologically, transformed tissues belonging to the tegumentary system of animals, and are hard, calcareous bodies, situated in the oral cavity at the anterior orifice of the alimentary canal. In the lower vertebrates they may be scattered over all of the bones and cartilages surrounding the mouth, but in the mammals, as in man, they are confined to the upper and lower jaws only. The name teeth, is therefore, in the latter, especially applied to those structures located in the oral cavity which contain a calcified tissue known as dentine.

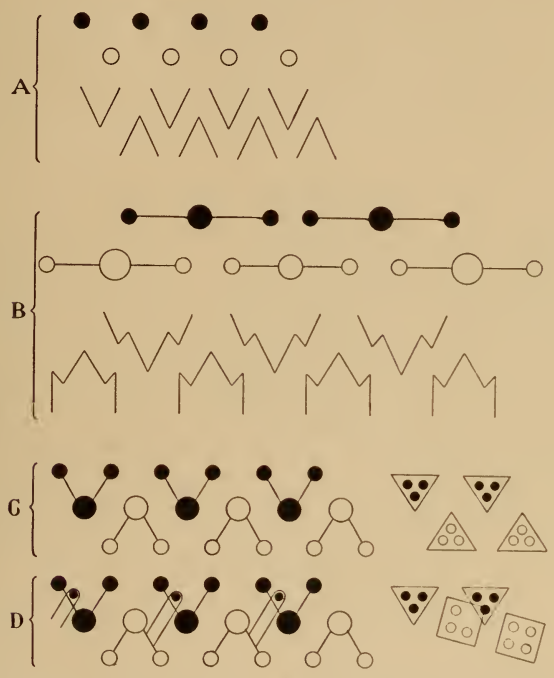
The *main function* of the teeth is the prehension and mechanical subdivision and reduction of substances employed for food, preparatory to digestion. The main divisions of this function are: (1) Prehension, or the seizing of food substances; (2) division, or cutting into pieces; (3) mastication, or comminution into small particles, and (4) insalivation, or the mixing of food with the oral secretions. For the performance of these various functions, different forms of teeth are developed in different animals in great variety. For the office of prehension, long trenchant canines are developed in lower mammals, but in man these teeth are reduced to the level of the other teeth. Division and cutting are performed by the incisors, which are well developed in man. Crushing and mastication are performed by the premolars and molars, which in man are much reduced and modified, owing to his omnivorous diet. The denture of man is midway between the extreme form of the carnivora, on the one hand, and herbivora, on the other. Food selection has reduced the denture of man to a simple type, which is quite primitive, showing evidences of reversion. The functions of the teeth in man being less

specialized than in lower, highly specialized animals, his denture is correspondingly reduced, function being here, as ever, the cause and sustainer of structure.

The primitive tooth form is that of the simple cone. This is still found in the teeth of fishes, reptiles, and some lower mammals. The more complicated teeth of the higher mammals have been formed by the modification of the single cone. Thus the incisors and canines are composed of single cones, the bicuspids of two cones fused together, and the molars are formed of three or more cones arranged to form triangular or quadrangular crowns. In the genesis of tooth forms, therefore, the complex teeth, as the bicuspids and molars, are formed by the repetition and addition of cones and their accompanying cusps, both laterally and longitudinally of the jaw. The transition from single to complex teeth is accomplished by the repetition of the single cone in various directions. Thus a bicuspid is formed by the evolution of a cingule upon the lingual side of the buccal cone, which gradually develops into a lingual cone with cusp and root, as illustrated in the double cone shape of the upper first bicuspid of man. The upper molar crown is developed as follows: The primitive simple cone, the primordial element, is called the *protocone.* The first cone (Fig. 1, *A*) and the first step in molar formation is the growth of cusps upon the mesial and distal aspects of the protocone (Fig. 1, *B*). The mesial cusp is called the *paracone* and the distal the *metacone.* This gives three cusps in a mesio-distal line, forming a three-coned crown called the triconodont type. This is the type of the early forms of the mammalian molar teeth, and is still preserved in some of the carnivora, seals, lemures, etc. The next stage is the shifting of the cones so as to alter their relative positions to form a triangle (Fig. 1, *C*). In the upper jaw the protocone moves to the lingual side and becomes the mesio-lingual cusp, leaving the paracone as the mesio-buccal cusp and the metacone as the disto-buccal cusp, which come together on the buccal side, thus forming the trigon of the upper molar. This is the tritubercular crown of early geological times from which all other molar types were developed, and is still preserved in the opossum, some insectivora, and some other modern mammals. In the lower molars the primitive cone is called the *protoconid*, but it moves to the buccal side and becomes the mesio-buccal cusp. The paraconid has been aborted in man, so that the *metaconid* becomes the mesio-lingual cusp, which forms the trigonid of the lower molar crown. Thus the triangles of the upper and lower molars alternate—the apex of the upper molar being directed lingually and the lower bucally, so that they pass each other with a shear-like motion. The next stage in the evolution of the molar crowns is the addition to the trigon of the upper molar on its disto-lingual face, of a heel, or talon (Fig. 1, *D*), which supports the fourth cusp, the *hypocone*, which strikes into the centre of the trigonid of the lower molar, like a pestle into a mortar. Then there is added to the trigonid of the lower molar on its

distal side, a heel, or talonid, which supports two or three cusps—the buccal, which is called the *hypoconid;* the disto-buccal, the *hypoconulid;* and the disto-lingual, the *entoconid.* Sometimes there is developed on the lingual face of the upper molar a fifth cusp which is called the hypoconule. This is the counterpart of the fifth cusp of the lower molar, the hypoconulid. This is the phylogenetic history of the molars in man, which are quite primitive in type, but their evolution can be readily traced in beautiful completeness.

FIG. 1



The phylogenetic history of the molar cusps: *A*, the single cone, the reptilian stage; *B*, lower mammals, the triconodont crown; *C*, the tritubercular molar, the trigonodont crown; *D*, the quadritubercular molar crown.

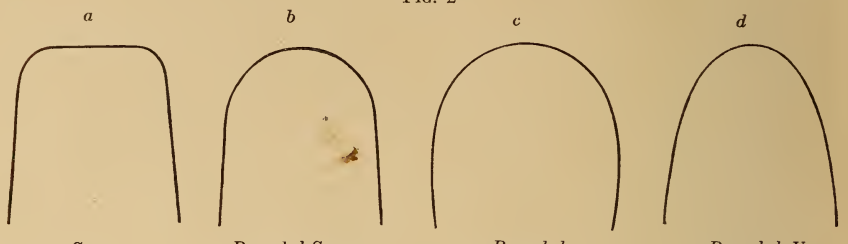
The Dental Arch.—The teeth of man are arranged around the margins of the upper and lower jaws in close contact, and have no interspaces between them. The basal arch is a graceful parabolic curve, with some variations which lead from the round arch to the incomplete parallelogram or even to a well-defined V-shape. These variations may be classified as follows:

First: *The Square Arch* (Fig. 2, *a*). This is found usually in persons of strong osseous organization, of Scotch or Irish descent—*i. e.*, of Gaelic extraction—and is probably derived in the first instance from a dolichocephalic people. The squareness is more or less dependent upon the prominence of the large canines, which stand out very markedly at the

angles of the square. The incisors present a flat front and project slightly, with little or no curve of the incisive line. The bicuspids and molars fall backward from the canines with no perceptible curve. The two sides are quite parallel, but sometimes there may be a slight divergence toward the cheek at the rear. This is the low form of arch which appears in the apes and some low races.

Second: *The Rounded Square* (Fig. 2, *b*). This is the medium arch, and is the form usually met with in ordinary, well-developed, robust Americans. The canines seem to be only sufficiently prominent to give character to the arch without a resemblance to the arches of the lower animals. The incisors are vertical and the line curves slightly from one canine to the other. The bicuspid-and-molar line curves slightly outward from the canine and converges at the rear.

FIG. 2



The main types of the dental arch.

Third: The *Rounded Arch* (Fig. 2, *c*). This is the circular or "horseshoe" arch. It is nearly semicircular, the ends curving inward at the rear, the outlines of the arch tracing a decided horseshoe shape. The canines are reduced to the level of the arch, so that there is no prominence of these teeth. The bicuspids and molars follow the line of the curve. This arch is quite characteristic in some races, as the brachycephalic South Germans.

Fourth: The *Rounded V* (Fig. 2, *d*). In this form the round arch is constricted in front or narrowed so that the incisors mark a small curve whose apex is the centre. It is the arch of beauty, and is that most admired in women of the Latin races.

These are but the basal forms of the dental arch. Ordinarily, modifications of these types occur in all degrees; it is the variations, the composites, which are most met with.

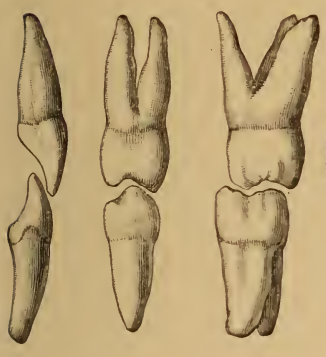
The Occlusion of the Teeth.—The upper teeth describe the segment of a circle larger than that of the lower teeth; so that the edges of the anterior teeth above close over those below, and the buccal cusps of the grinding teeth above close outside of the buccal cusps of the lower teeth (Fig. 3). By this arrangement the buccal cusps of the lower grinders are received into the depressions or sulci between the buccal and lingual rows of the cusps and tubercles of the superior molars and

bicuspids, and the lingual cusps of the upper grinders are received into the sulci of the lower grinders. By this arrangement the whole of the morsal surfaces of these teeth are brought into contact in the several movements of mastication, thereby rendering the performance of this function more effective.

Then, again, the upper incisors usually close over the lower for one-third of their length. This allows of the shearing action by which the incisive function is performed as the edges of these teeth are drawn past each other.

The *line of the horizon of occlusion* (Fig. 4, *A* to *B*) presents a decided curve from front to rear, of greater or less degree in different forms of the arch. Thus it is high at the incisors, curving downward at the bicuspids, reaching its lowest point at the first molar; it curves upward

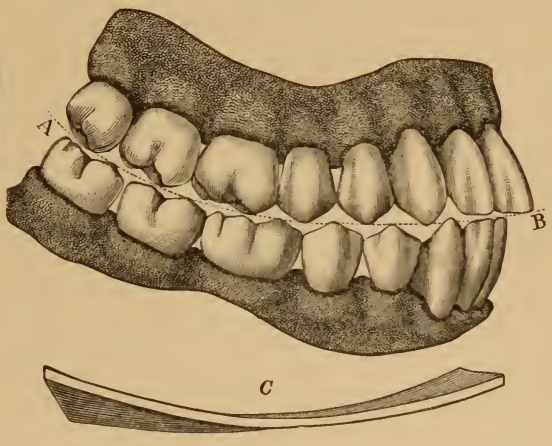
FIG. 3



Incisors. Bicuspids. Molars.

The relative position of the upper and lower teeth in occlusion.

FIG. 4



The horizon of the line of occlusion and plane of occlusion.

rapidly at the second molar, and is highest again at the third. In the round arch the plane is more flattened and exhibits the extreme downward curve in the square arch. Between these extremes there is, of course, every variety of modification. The form of the plane of occlusion is shown in Fig. 4, *C*.

The tendency of the bolus of food is toward the lowest part of the curve at the region of the lower first molar, so that the extraction of this tooth always affects the performance of mastication.

In the *apposition of the teeth* of the opposite jaws the mechanical arrangement is such that the dynamics of mastication is subserved and the greatest effectiveness secured (Fig. 5). Thus the morsal surface of the upper central incisor is opposed to all of that of the central incisor below and to the mesial half of the lateral; the upper lateral

opposes the distal half of the lateral below and the mesial face of the canine; the upper canine, the distal half of the face of the lower canine and the mesial half of the first bicuspid; the upper first bicuspid opposes the distal half of the lower first bicuspid and the mesial half of the second; the upper second bicuspid opposes the distal half of the lower second bicuspid and part of the lower first molar; the upper first molar opposes the distal part of the lower first molar and the mesial half of the second; the upper second molar opposes the distal half of the lower second and part of the third; and the upper third covers the remainder of the lower third molar.

Fig. 5



The apposition of the upper and lower teeth.

By this method of apposition the teeth are so arranged that two teeth receive the impact of half of two of the opposite jaw, thus distributing the force of occlusion and insuring the safety and strength of the teeth. This "break-joint" arrangement permits each tooth to bear two opposing ones, and also helps to preserve the alignment. Then again if one tooth be lost the opposing teeth still rest against two teeth, one at each side of the space. The normal condition of the articulation is rarely preserved, however, as mutilation usually disturbs it; the teeth move on account of the force of occlusion, and effective mastication is more or less destroyed.

Number and Classes of the Teeth.—Man has thirty-two teeth, divided into four classes, viz.: (1) *Incisors;* (2) *canines*, or *cuspids;* (3) *premolars*, or *bicuspids;* and (4) *molars* (Fig. 6). This is expressed by the dental formula as follows:

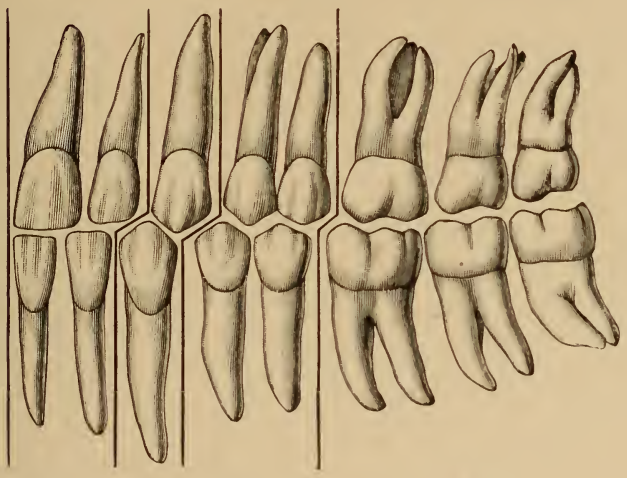
$$i.\ \frac{2-2}{2-2},\ c.\ \frac{1-1}{1-1},\ bi.\ \frac{2-2}{2-2},\ m.\ \frac{3-3}{3-3} = 32.$$

1. The **incisors** are eight in number, four above and four below—two on each side of the median line. The two next to the median line are called the *central incisors,* the ones next to them distally the *lateral incisors.*

2. The **canines,** or **cuspids,** are four in number, two above and two below—one on each side immediately approximating the lateral incisor on the distal side.

3. The **premolars,** or **bicuspids,** are eight in number, four above and four below—two on each side approximating the cuspids on the distal side. The first of these next the cuspid is called the *first bicuspid,* the one next to it on the distal side the *second bicuspid.* The same designation applies to both upper and lower bicuspids.

FIG. 6



Incisors. *Canines or cuspids.* *Premolars or Bicuspids.* *Molars.*

The classes of the teeth, comprising the left half of a full denture.

4. The **molars** are twelve in number, three on each side of each jaw, approximating the second bicuspid on the distal side. The molar next to the second bicuspid, both above and below, is called the *first molar;* the next one distally is called the *second molar;* the next one distally, and the last tooth in the jaw, is called the *third molar,* or "wisdom tooth" (*dens sapientiæ*).

Functionally, the incisors are formed for cutting, as their name implies; the cuspids for prehension and tearing (for which purpose this tooth in lower animal forms is often excessively developed). It also serves in guiding the bite. The bicuspids are the crushing teeth, and the molars are formed for grinding, triturating, and insalivating the food.

The Incisors.—The function of cutting and dividing food is performed by various organs throughout the animal kingdom, and even

cutting teeth are found very low down in the scale of life. The cephalopods have cutting teeth on the odontophore; the insects, some worms, as the leech and other low forms, cut by means of sharp or saw-edged mandibles; in the sea urchins true incisor teeth are found which simulate the incisors of rodents. The fishes and reptiles have no true incisors. However, in the fish *sargus*, incisor-like teeth are found, and the turtles have the jaws sheathed in a horny covering with sharp edges. Some aberrant fossil reptiles have cutting teeth also, but these are exceptions to the rule. The lowest mammals are deficient in cutting teeth, but have simple conical teeth in all positions in the mouth, like the reptiles. The herbivora have highly developed incisors in all species. In the carnivora the incisors are much reduced, as their function is usurped by the premolars, which have long blades for cutting flesh. In the quadrumana the human type of incisor appears and develops progressively from the lemurs to the higher apes, in whom the human type is well developed.

The Upper Central Incisor.—This is the first tooth in the dental series in man. It is situated in the front of the mouth, next to the centre of the arch, which is the mesial border of the intermaxillary bone. In adult man these bones fuse with the anterior borders of the right and left superior maxillary bones. Their junction with each other marks the centre of the dental arch.

The *general form* is that of a truncated cone with its top flattened out to form the cutting edge.

The *form of the crown* is spade-like, or a compressed-wedge shape, the edge being quite thin and the thickness increasing rapidly to the base. It is slightly bent toward the lingual side, or much curled over in some cases.

The *labial face* is imperfectly square or oblong, the cervical margin being rounded (Fig. 10, *a*). It is convex from side to side, but only slightly so from cervix to edge. Two shallow depressions or furrows extend the length of the face perpendicularly (*b*), dividing it into thirds, called *lobes*—the mesial, (*c*), median (*d*), and distal lobes (*e*). These furrows and lobes are quite conspicuous when the tooth is erupted, but are abraded by age and the wear of use and dentifrices, until the face becomes smooth. The mesial margin is a little longer than the distal, so that the cutting edges slope upward toward the distal side (*f*).

The *lingual face* is smaller than the labial, being on the inner and smaller curve of the crown, and is narrower from side to side (Fig. 7). It is triangular in outline, being wide at the edge and narrow and rounded at the base or cervix. The marginal ridges (*a*) are high and conspicuous, and extend from the basal ridge to the edge on the mesial and distal margins of this surface. The basal ridge (*b*) is a strong elevation continuous with the marginal ridges at the base of the crown. It is sometimes developed into a raised cusp, the ridge at the base of which forms a cingulum. A ridge or lobe (*c*) extends from the basal ridge to the centre of the

edge, uniting with the median lobe from the labial face to form the median tubercle. A depression or fossa (*d*) is found on each side of the median lobe between it and the marginal ridges, or, when the lobe is low or entirely absent, these fossæ may be continuous. A *fault*, or *fissure*, at its junction with the basal ridge frequently forms the seat of caries.

The *mesial* face (Fig. 8) is a rather long triangle in shape, with a concaved base at the cervix of the tooth (*a*) and a long point toward the edge. It is nearly straight in a longitudinal direction, but rounded and convex transversely. It is longer than the distal face, the edge descending in that direction. The enamel line dips downward into this face, and there is a depression above it (*b*) which sometimes extends upward on the root. The point of contact with the opposing tooth is near the cutting edge.

Fig. 7

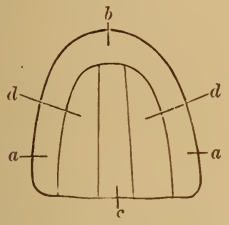
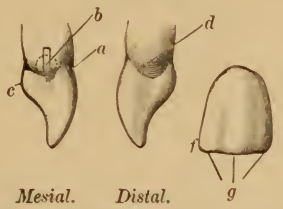


Diagram of the lingual face of the upper central incisor.

Fig. 8



The mesial and distal faces and edge of the upper central incisor.

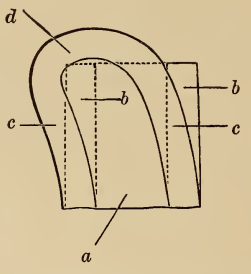
The *distal* face is also triangular in outline (Fig. 8), but it is more curved in the longitudinal axis, so that this surface is convex in all directions. It is most curved in the transverse direction. The enamel dips downward into the surface (*d*), as in the mesial, but there is not so much of a depression above this line. The point of contact is one-third of the distance from the angle (*e*).

The *edge*, or *morsal* margin, of the crown is formed by the compression of the top of the truncated primitive cone. It is quite wide and square except at the distal corner, which is rounded. The angle with the mesial face is acute (Fig. 8, *f*). When the tooth is first erupted, the edge has three prominent tubercles (*g*), which correspond to the ridges on the labial and lingual faces. These are soon worn off with use, so that the edge usually looks straight. The pitch of the edge is toward the median line.

The *mechanical structure of the crown* is a matter of importance. It will be observed that it consists of several elements: first, a broad cutting blade (Fig. 9, *a*) supported by two strong lateral columns (*b*) on each side, and that these columns are upheld by two strong marginal ridges (*c*) leading up from the lower ridge (*d*). These ridges are *buttresses* which guy and uphold the columns which contain and carry the blade. Hence, when these ridges are destroyed by caries or in operating the support of the column is lost and the blade readily breaks away.

In operations upon this tooth, this blade-like structure must be constantly borne in mind, for weakening of the elements of the crown may easily result from excessive cutting. The columns of support can be better preserved with the inlay filling than with pressure fillings which require more strength of walls. Less cutting away is required, and the contour can be better preserved and supported by the inlay and cement. A better esthetic effect is also thereby obtained. Small cavities in these teeth are, of course, better filled with pressure gold fillings, but larger ones are better treated by fillings with porcelain inlays, care being taken to preserve as much tooth substance as possible, to attain the best artistic and mechanical results. Fragile enamel margins should not be retained, of course, but when backed by dentine the walls should be preserved—especially when parts of the supporting columns of the crown.

FIG. 9



The mechanical design of the crown of the upper central incisor: *a*, the blade; *b*, the two columns supporting the blade; *c*, the marginal ridges acting as guys, bracing the columns; *d*, the basal ridge at the base of attachment for the guys.

FIG. 10

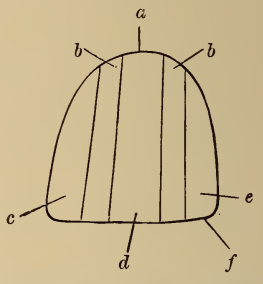


Diagram of the labial face of the upper central incisor.

The *neck* of the central incisor is a rounded pear-shape in outline, the labial half being wider (Fig. 11, *a*) than the lingual. There is not much constriction of the tooth at the neck. The enamel edge curves upward on the root on the labial and lingual sides, and dips downward on the mesial and distal faces. It terminates abruptly on all sides, especially on the lingual, where a considerable ridge is sometimes raised (Fig. 10, *c*).

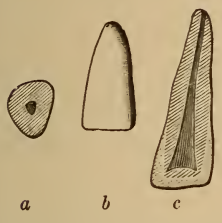
The *root* is cone-shaped and tapering (Fig. 11, *b*). The rounded pear-shaped section continues almost to the end.

The *pulp chamber* is spacious and open, and of the general form of the tooth (*a* and *c*). The radical portion of the canal gives free access, but the flattened coronal portion is difficult to cleanse. In young teeth the cornua or horns of the pulp may project far toward the angles (*c*).

The Lateral Incisor.—This tooth approximates the central incisor on its distal side, and is also implanted in the intermaxillary bone. It is of similar spade-like form and of the same architectural design as the

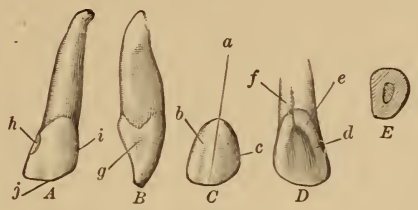
central, modified by the distal half being more rounded in every direction. As the crown is narrower than the central, the destruction of the marginal ridges on the lingual face weakens the edge still more, so that it breaks off more easily. The crown is narrower in the mesio-distal diameter than the central, but, still almost as wide labio-lingually, the relative difference of thickness in the two directions is more apparent. The tooth has the appearance of being compressed mesio-distally. The thickness increases rapidly from the edge to the neck (Fig. 12, B).

Fig. 11



The root of the upper central incisor.

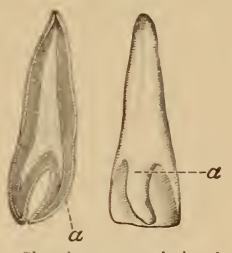
Fig. 12



The upper lateral incisor.

The *labial face* (Fig. 12, *C*) is more rounded than that of the central. It is half incisor and half cuspid (*a*), the mesial half toward the central incisor resembling that tooth (*b*), and the distal half toward the cuspid resembling it (*c*). The mesial angle of the edge is quite acute, while the distal angle is rounded and obtuse. The three lobes may be well developed, similar to those on the central incisor, but are usually indistinct, although the central ridge is prominent.

Fig. 13



Showing unusual development of the cingule or basal talon on an incisor. (From case reported by Dr. W. H. Mitchell, Dental Cosmos, vol. xxxiv. p. 1036.)

The *lingual face* (Fig. 12, *D*) is much depressed, but less concave than that of the central incisor. The marginal (*d*) and basal ridges (*e*) are quite prominent. The basal ridge is often raised into a permanent cingule or talon, an exaggerated example of which is shown in Fig. 13, which is a revival of the basal talon found in the apes—and the insectivora. This cingule occurs more frequently on the lateral incisor than on any other of the anterior teeth. The depression above it is often the location of a fault, a fissure or pit, which becomes the seat of caries. The basal ridge is sometimes cut by a fissure which leads down quite upon the neck of the tooth (Fig. 12, *f*). Sometimes the entire surface is full and rounded without any concavity whatever.

The *mesial face* (*g*) is of triangular form similar to that of the central incisor. It is rounded toward the edge labio-lingually, but flattened at the neck, with a depression at the enamel line which leads upward upon

the root. The labial angle is sometimes the seat of a depression (*h*), which gives the angle a hook shape. The depression varies in width and depth, and may become the seat of caries. The point of contact with the central incisor is at the junction of the lower with the middle third of the length of the face.

The *distal face* is more convex in all directions, and resembles the canine in form, being in harmony with the general form of the distal half of that tooth. From cervix to edge it is rounded and the contact eminence in the middle third is very full (*i*). From this point it rounds off rapidly to the edge. The upper third is depressed rapidly toward the cervix, with a considerable depression at the enamel line leading off to the distal groove on the root.

The *edge* is divided into two portions by the prominent tubercle (*j*) in the middle which terminates the prominent central ridge of the labial face. The mesial half is straight, like that of the central. When worn, these features disappear and the edge becomes almost straight. The pitch of the edge, like that of the central, is toward the median line.

The same mechanical structure of the crown is found in the lateral as in the central, except that the crown is more slender and weaker, so more precaution must be observed to prevent breaking during and after operating upon it.

The *neck* is much flattened mesio-distally, and is of a compressed pear shape, or flattened oval on section. The enamel margin pursues the same course as on the central incisor, rounding upward toward the root on the labial and lingual sides and dipping downward on the distal and mesial. It does not terminate so abruptly as that of the central incisor, and presents less of a ridge at the gingival margin.

The *root* is commonly longer than that of the central incisor, is narrower, flattened mesio-distally (Fig. 12, *A*, *B*). It tapers gradually, not rapidly like the root of the central incisor. It is a flattened oval on section (*E*). Sometimes there is a hook at the end, curved distally. Grooves sometimes occur on the mesial and distal sides.

The *pulp canal* is flattened in conformity to the shape of the root, but is readily entered if the root be straight.

The lateral incisor is very irregular as to form, presenting various degrees of deformity or abnormality, and may sometimes be reduced to a mere peg. It is also erratic as to eruption, being sometimes suppressed, not appearing for several generations of a family. It follows the third molar in the frequency of its irregularities both as to form and frequency of non-eruption.

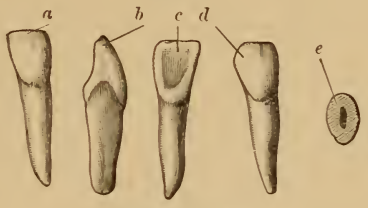
The third incisor of the primitive typal mammal sometimes reappears in man, and is known as a supernumerary. It rarely assumes the proper incisor form and position in the arch, but usually erupts within the arch, and is a mere pointed peg-shaped tooth.

The Lower Incisors.—These are most conveniently described as a group, as they are very similar in form, having but slight variations between the central and lateral incisors to be noted.

They are located in the anterior portion of the lower jaw, upon each side of the median line, opposite the incisors above. Their function is the same as that of the upper incisors, the cutting of food, which they perform by opposing the upper. The lower central opposes only the central above; the lateral, both the upper central and lateral incisors.

The **lower central incisor** is the smallest tooth in the dental series. It is of spade-like form (Fig. 14), the crown being a double wedge shape (*a*, *b*). The first wedge (*a*) is observed on viewing the crown from the front, the widest portion being at the morsal edge and the point at the cervix. The second wedge is observed from the side (*b*), the widest part being at the neck and the point at the morsal edge of the crown. The edge is thin, but the labio-lingual diameter increases rapidly to the cervix, which is the widest part. The crown is widest mesio-distally at the edge, but diminishes to the neck, which is scarcely more than half the width of the edge. The tooth cone is therefore compressed in one direction at the edge, and in another at the cervix. The mechanical elements are the same as those of the upper central, but with the parts less strongly marked.

FIG. 14



The lower incisor.

The *labial face* is a long wedge shape (*a*), the widest part at the edge and narrowing to the cervix. It is usually straight, or nearly so, longitudinally, and straight across the edge, but round and convex at the neck and the cervical half. Sometimes vertical ridges are found on these teeth when they are first erupted, but these soon wear off.

The *lingual face* is depressed and concave from edge to cervix (*c*), but less so from side to side. The marginal ridges are often well marked. In the lateral incisor the fossa is often more marked and the marginal ridges more distinct.

The *mesial* and *distal* sides are of wedge-like form, straight from edge to cervix and widening in the same direction. A depression runs across the neck just above the enamel line.

The *neck* is much compressed disto-mesially, and the root partakes of this flattening through its entire length. The section presents a compressed oval (*e*), The enamel line dips downward on the labial and lingual sides, and curves upward on the mesial and distal in a manner characteristic of the incisors.

The *edge* is perfectly straight from side to side, after the three tubercles, found when first erupted, are worn off.

The *root* is flattened like the neck, and frequently a groove runs the

entire length on the mesial and distal sides. Occasionally complete bifurcation results, which recalls the form of this tooth found in lower animals.

The *pulp canal* (*e*) is of similar form to the root, and is flattened and thin, so that it is often difficult to effect an entrance to it with instruments.

The **lateral incisor** is similar in form to the central incisor, but is wider at the edge, and the distal corner of the edge is slightly rounded (*d*). In all other features it resembles the central incisor.

The **canine**, or **cuspid**, appears very early in the history of vertebrate life in its prototype, the single conical tooth of fishes and reptiles. The conical form of the canine is maintained down through all the succeeding stages to man, with mere variations as to contour, as manifested in the higher vertebrates. It is the tooth of prehension from the lowest to the highest forms. As prehension is the most primitive of tooth functions, so the conical, canine tooth is the primitive tooth. In the higher mammals it is probably modified from the premolar series, as it is the first tooth posterior to the intermaxillary suture. In the lower mammals it is variously modified, but it is in the carnivora that it attains its highest specialization. Its greatest development was found in the extinct felidæ, where it was long and sabre-shaped, with sharp serrated edges, as in the cave lion and bear and the fossil forms of America. The living cats, the lion, tiger, leopard, etc., have the highest forms of this tooth, but it is reduced in the dogs and bears and other omnivorous forms. In the quadrumana the canines are well developed, and in the apes they are very large and strong, and are formidable weapons. Owing to the continued absence of the "missing link," there is a sudden transition between the higher apes and man, as they are much reduced in the latter, being brought down to the level of the other teeth. Indeed, the canine presents more points of divergence from the form of this tooth in the anthropoid apes than any of the other teeth, all of which resemble those of the apes very closely. It is practically a crushing tooth in man as prehension is in abeyance as a human dental function.

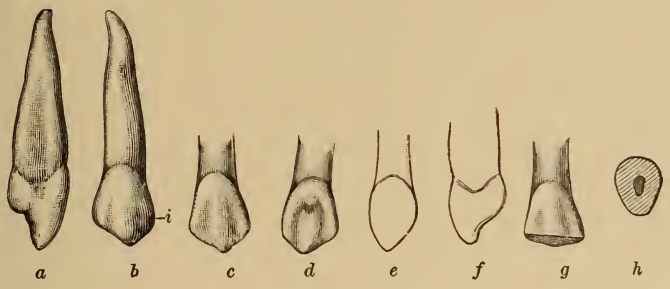
The Upper Cuspid.—This is the third tooth from the median line, and approximates the lateral incisor on its distal side. It is the first tooth posterior to the intermaxillary suture, and is embedded in the maxilla proper. It is commonly said to form the spring of the arch, and conveys the impression of great strength, as is indicated by its strong implantation. It is more strongly implanted, and by a longer and larger root, than any of the other teeth. Zoölogically it is the largest tooth in the dental series, but in man is much reduced from its prototype, the larger carnassial canine of lower animals, especially the carnivora. It is the principal prehensile tooth, and is therefore first in order of function in the dental series.

The *crown* has a spear-head shape (*b*), hence its name, cuspid, from

the Latin *cuspis*, "point, pointed end." It is constructed essentially for piercing and tearing. The central cusp or point is braced in all directions; the edges leading up to it both mesially and distally (which serve for cutting as well), the strong labial ridge coming downward from the cervix (*c*) to the median ridge leading up on the lingual surface (*d*), all support it in the office of prehension and the laceration of flesh.

The *labial face* (*b*) presents the outlines of the spear shape, more or less rounded in different cases. Starting from the well-defined cusp just in front of the central axis of the tooth, it widens sharply for about one-third of its length, whence it narrows gradually to the gum line, which is fully rounded. In some cases the mesial and distal angles are rounded and the outlines are more of a leaf shape (*e*). The surface is slightly rounded mesio-distally, so that the sides slope roundly or flatly away from the central ridge. This ridge descends from the middle of the cervical margin, curving slightly forward and then backward to the

FIG. 15



The upper cuspid.

point of the cusp (*c*). This curve recalls the curving shape of this tooth in the felidæ. It is usually a sharp, prominent ridge, but may be reduced and rounded so as to be scarcely perceptible. The three lobes of the surface are imperfectly marked—the central ridge dominating and dwarfing the lateral ones. The lateral furrows on each side of the central ridge separating it from the lateral lobes are more or less marked, especially toward the edge. Wear reduces in time the prominence of the lobes and ridges and obliterates the furrows.

The *lingual face* is of similar spear-shape (*d*), but is more flat. It is rarely concave. The thickness of the crown increases gradually to the lateral prominences, which gives a blade-like edge, then rapidly to the shoulder at the base. A strong vertical ridge extends from the cusp to the basal ridge (*d*), with a slight concave depression on each side. The basal ridge is well marked and sometimes develops into a cingule, more or less marked. The marginal ridges lead up on each side only so far as the lateral protuberances. They are not strongly marked as a rule. The

fossæ on each side of the vertical median ridge, between it and the marginal ridges, may be quite deep, but are usually shallow and ill defined.

The *mesial* face in outline is not unlike the central incisor, but its contour is very different, for it is more or less rounded in all directions, and the lateral eminence in the lesser third makes this part especially full (*i*). From this point the surface is depressed roundly to the enamel line at the neck, where a depression of greater or less depth is found. It is somewhat flattened at the cervix. The point of contact is at the eminence, which touches the lateral incisor.

The *distal* face is of similar form to the mesial, except that it is more full and the eminence more pronounced, which gives the increased width of the crown on that side. The surface descends rapidly toward the neck and is rounded labio-lingually. The point of contact with the first bicuspid is on the lateral protuberance.

The *morsal* edge presents a prominent cusp, which is almost central to the long axis of the tooth. The side facets slope away, but still retain their cutting edge (*b*). The distal side of the edge is longer than the mesial, by reason of the increased size of the distal protuberant angle. The sharp point is soon worn off to a rounded cusp, and, as wear increases with age, it may be reduced to a straight surface between the mesial and distal protuberances (*g*).

The *neck* is a flattened oval on section, or the lateral direction of the labial portion may be greater than that of the lingual (*h*). The enamel line preserves the same curves as on the incisors, *i. e.*, rounding upward on the labial and lingual surfaces and dipping downward on the mesial and distal. The enamel terminates gradually with but a slight ridge, unless it should be on the lingual side. A depression occurs on both mesial and distal sides above the curve, which may lead up as a groove on the root.

The *root* is longer than that of any other tooth, and it is at least one-third larger than that of the central incisor. It is of a rounded trihedral form, or irregularly conical. It is usually straight, and tapers to a slender point, which may be curved or very crooked. In well-arranged dentures, where it has erupted naturally, it is usually straight.

The *pulp canal* is large and open, of the same form as the tooth, and easily entered. It is regularly formed except in those cases where the root is curved, and even in these it can be filled if not too crooked, as it is so open and accessible.

The Lower Canine.—This is similar to the upper in form and outline, except that it is somewhat smaller, more slender, and more rounded in form (Fig. 16, *a*). It differs also in being more compressed mesio-distally and in being flattened in the neck and root. The crown leans backward on the root so that the mesial face is almost straight the entire length of root and crown. It forms the spring of the lower arch, and is strongly built to oppose the strong upper canine in the act of prehension and

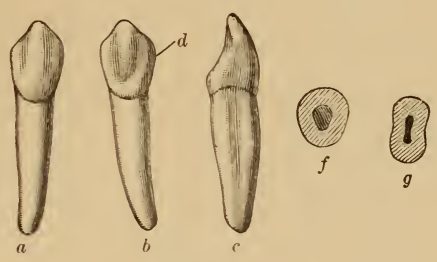
tearing. It opposes the mesial surface of the canine above and the distal surface of the upper lateral incisor.

The *labial face* is a long oval (*a*), the cusp being blunt and the neck rounded while the mesial side (*c*) is flattened. The lobes are indistinct and the central ridge is rounded from side to side. The entire face is inclined inward to accommodate the occlusion. The crown in many cases presents the appearance of being blunt toward the distal side.

The *lingual face* (*b*) is flat, sometimes cup-shaped, and the marginal ridges are not prominent. The central ridge sometimes stands out strongly. The basal ridge is weak and is rarely developed into a cingule. The crown increases gradually in thickness from the point to the neck.

The *morsal surface* presents a mere rounded eminence; the cusp may be sharp in childhood, but usually it is soon reduced by wear. Sometimes it remains sharp and prominent. The lateral edges are not developed, but are mere ridges leading down to the lateral faces, which are not prominent, except the distal (*d*), which is often full.

FIG. 16



The lower canine.

The *mesial face* is quite flat, and straight with that face of the root. The eminence is not marked. It is rounded only at the eminence, but flattened at the cervical third (*c*).

The *distal face* has the most prominent eminence (*d*), the crown being bent in that direction. The cervical third of this face is flat. It descends rapidly from the eminence.

The *neck* is usually oval (*f*), or, when compressed, spindle-shaped upon section (*g*), being depressed on the mesial and distal sides at the origin of the grooves running up on the root. The enamel line is not so variable as on the incisor, but more nearly on a level on all four aspects.

The *root* is long, flattened, and tapering (*a*, *b*, *c*). It is shorter than that of the upper cuspid. It is grooved on the mesial and distal sides—so much so as to tend toward bifurcation. This, indeed, sometimes happens in man, thereby recalling the form usual to the primates and some other lower animals.

The *pulp canal* is of the same general form as the root, often presenting the spindle-shape on section. It is somewhat difficult to enter on account of its flattened shape and narrowed channel.

The canine being larger, stronger, and more robust than the incisors, presents fewer elements of mechanical weakness of the crown than those teeth. The body of the crown is thicker from the cervix

to the morsal point, and is well supported labially by the rounded eminence of this face and lingually by the columns on *that* face. The median third of the crown is strong enough for self-support, even when the mesial and distal columns are destroyed, which is not the case with the incisor blade. The morsal point is still strong enough for serviceable employment in food reduction. This mechanical structure of the canine permits of more extensive operations upon the mesial and distal faces of the crown than is possible with the incisors, This obtains even with pressure gold fillings, and is, of course, much more applicable to inlay fillings. But the important fact must also be taken into consideration that the canine having been transplanted from the premolar series, in the process of evolution, is subjected to much more stress in the performance of its duties in food reduction than the incisors. In fact, most of the errors of operating upon this tooth are due to the fact that it is treated as an incisor rather than a premolar in its artificial restoration. The solidity of its support, the deep implantation, the strength of crown, all tend to encourage the instinctive hard usage which this tooth receives, an instinct which is partly inherited from the stage of evolution of the species when it was a useful and effective weapon. On account of this hard usage, operations upon this tooth must be planned for the endurance of great stress, in order that fewer failures shall result from misapprehension of its office.

THE TUBERCULATE TEETH

The very lowest forms in which grinding organs appear are the cusped prominences upon the stomacholiths, the gastric mill of the crustacea. The larval stage of some insects also have calcareous grinding organs in the stomach or proventriculum. In the lower vertebrates the crushing teeth appear first in the fishes which have well-developed pavement teeth for crushing shellfish. True tuberculate teeth do no appear, however, until the stage of the higher reptiles, some lizards having posterior tubercular teeth, which are the forerunners of the molar teeth of the mammalia. In the lower mammals the crushing and grinding teeth are very simple, as in the bruta, in which the crushing teeth are simple dentin cylinders, worn in facets. Gradual progress takes place in the evolution of the grinding teeth until the highly developed molars of the herbivora are attained, on the one hand, and the cutting premolars of the carnivora, on the other—both highly developed for reducing special kinds of food. Between these two extremes are many intermediate forms, variously adapted to omnivorous diets. Among these intermediate forms man is found, whose simple, tuberculate denture is adapted to an omnivorous diet. The grinding teeth of man are of primitive bunodont type, which recalls early geological forms of molars, harking

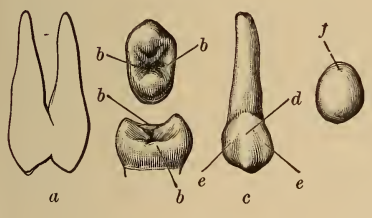
back to his ancestral prototype of the tertiary formations. The evolution of the human molars is a beautiful study—as has been previously illustrated.

The Bicuspids.—The bicuspids in man are homologous with the premolars of the quadrumana and other lower mammals. They succeed and displace the molars or grinders of the deciduous set. They are placed next after the cuspids in both jaws. and midway between the cutting and grinding teeth. Their function is the crushing of food preparatory to mastication.

The Upper Bicuspids.—The upper bicuspid is formed by duplication of the primitive cone and cusp in a transverse direction (Fig. 17, *a*). Viewed from the standpoint of comparative dental anatomy, the external cone is the *canine cone*—and to this is added the internal or *bicuspid cone*, the tooth being a double canine. The bicuspids are the first of the complex teeth. The internal cusp is formed by the raising of the inner primitive cusp of the cuspid and the development of a root to support it. The distinctive feature of the architecture, therefore, is its formation from two cones.

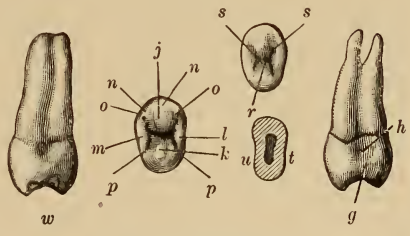
The **upper first bicuspid** approximates the cuspid on the distal side.

FIG. 17



The upper bicuspids.

FIG. 18



The upper bicuspids.

The *buccal face* (*c*) is of spear-head shape, similar to that of the cuspid. This is more apparent in some lower mammals than in man, in whom it is much reduced and rounded, so as to give usually the appearance of a long, rounded oval. The buccal cusp (*c*) rises sharply and prominently from the lower centre of the face, from which a strong ridge (*d*) leads up to the cervical border. The mesial and distal lobes (*e*, *e*) are rarely conspicuous, and the furrows between them and the central ridge lead but half-way up the crown. The lobes sometimes have prominent points at the morsal margins, which in lower mammals become pronounced cingulums. The buccal marginal ridges descend from the points of the cusp to the points of the lateral lobes. The distal ridge is usually longer than the mesial. The cervical border is rounded and oval from side to side.

The *lingual face* (*f*) is full and rounded, more or less straight perpen-

dicularly, and rounded mesio-distally. It is convex in both directions. The lingual cusp rises over it full, but is blunt and round; the marginal ridges are rounded, not angular, and curve sharply around to meet the mesial and distal marginal ridges.

The *mesial face* (Fig. 18, *g*) is wide and flat transversely, full at the morsal surface at the marginal ridge, which is prominent, and descending flat to the cervix, where a depression (*h*) occurs which extends well up the face.

The *distal face* is of similar form, but is rather more convex and the portion at the marginal ridge more prominent. The depression from the root does not extend so far up on the face.

The *morsal surface* shows an abrupt change from that of the cuspid next to it, as it presents two distinct cusps or points instead of one. One cusp is on the buccal margin (*j*) of the crown, and one on the lingual (*k*), and they are named the *buccal* and *lingual* cusps. The buccal cusp is sharp and prominent, and is not unlike the single canine cusp. The lingual cusp is broader and more rounded—indeed, it is preferable to term it a tubercle.

The outline of the morsal surface is imperfectly quadrate and is bordered by well-marked marginal ridges, named as follows:

The *mesial* marginal ridge (*l*), bordering the mesial face of the crown; the distal marginal ridge on the distal side (*m*), the *buccal* marginal ridges (*n*) descending from the point of the buccal cusp to meet the buccal terminations of the distal and mesial marginal ridges at the angle formed by the junction with the buccal lateral lobes (*o*), and the *lingual* marginal ridges (*p*), descending from the lingual tubercle to meet the lingual termination of the mesial and distal marginal ridges.

The *triangular* ridges descend from the cusps toward the centre of the tooth and unite at the central groove In defective teeth they do not fuse, leaving a fault or fissure which usually becomes the seat of caries. This groove or sulcus extends from one lateral marginal ridge to the other mesio-distally (*r*), and widens into the mesial and distal sulci at each end. The triangular grooves (*s*) run from the mesial and distal sulci toward the mesial and distal angles, dividing the marginal ridges from the triangular. They also frequently become the seat of caries in imperfectly formed teeth.

The *neck* of the first bicuspid is compressed or spindle-shaped (*t*), the enamel line rising on the buccal and lingual sides and dipping down on the mesial and distal. The enamel margin tapers off gradually on to the root. A wide, deep depression usually occurs (*u*) on the mesial side of the neck, leading to the groove on the root. On the distal face this is not so well marked.

The *root* is much flattened mesio-distally, with a decided groove extending up both sides. This grooving tends to cause bifurcation of the root, which actually occurs in one-third of the cases, especially in persons

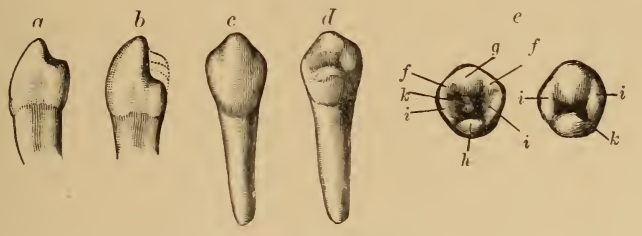
of strong build. This bifurcation is a persistent relic of lower forms of the premolars, as in the apes.

The *root canal* is flat at the neck, and nearly always bifurcated, even when the root is not separated. This is readily seen by holding a bicuspid having one root, up to the light, when the central portion will be observed to be translucent. The usual bifurcation necessitates the search for both canals in every case in treating this tooth.

The **upper second bicuspid** (*w*) approximates the first on the distal side, and is similar to it in every way, except that it is usually smaller and more rounded in all directions. The sharp features, conspicuous ridges, etc., are not so strongly marked. The cusps are reduced, the ridges more rounded, and the morsal face more flattened, and it is often wrinkled. The triangular ridges are more likely to be united, thus making the crown stronger. The crown is thinner mesio-distally. The neck is more rounded or oval.

A most conspicuous difference is in the *root*, which is narrower labio-lingually, is more rounded, and is rarely bifurcated. It is sometimes cylindrical or cubical in form. It is disposed to be turned, and is often crooked. The *pulp canal* is single and readily entered.

FIG. 19



The lower first bicuspid.

The Lower Bicuspids.—These are placed next after the lower canines on the distal side. In form they are not truly bicuspid, for the first is unicuspid and the second is tricuspid in the pure typal forms; but they are arbitrarily termed bicuspids on account of their position as compared with the upper bicuspids, which are typically bicuspid.

The architectural form of these teeth is that of the single cone, the crown being augmented in various directions by the addition of cingules to the primitive cusp.

The **lower first bicuspid** is a well-formed transitional tooth, for it grades from canine to bicuspid and is typically composite. It more closely resembles a canine than a bicuspid in its usual form, because the inner cusp is almost suppressed and is rarely as large as the outer one (Fig. 19, *a*). In fact, it looks like a canine with a cingule raised upon its inner face. This cusp is really a cingule, for it is rarely raised to the full height of a cusp.

It varies much in size from a mere point on the basal ridge (*b*) on through various degrees of development, up to a full cusp as large as the buccal cusp, when the tooth becomes a true bicuspid. The tooth is therefore essentially a primitive unicuspid premolar, of the form of this tooth in some of the lower primates.

The *buccal face* (*c*) is caniniform, or a long oval in outline, with the cusp rising as an abrupt point above it. The angle of the junction of the marginal ridges may stand out prominently. The face curves markedly toward the lingual side, so that the buccal cusp becomes central to the long axis of the tooth (*a*). The cervical border is rounded at its margin and convex from side to side. The lobes are not marked.

The *lingual face* (*d*) is convex from side to side and straight vertically, but is not perpendicular, as it is directed toward the lingual side. Its height depends upon the height of the lingual cingule, which varies from a mere buccal ridge through various degrees up to the full-sized cusp.

The *mesial* and *distal surfaces* are of similar form, convex from side to side (*a, b*), slightly flattened at the cervical border and flaring out to meet the full marginal ridges, which are round and prominent. The prominence of these ridges and the inward inclination of the lingual face gives the crown a decided bell shape, tapering to the neck (*d*).

The *morsal surface* (*e*) is peculiar and differs from every other tooth in its great variability and the extremes which it may present, from being that of a full bicuspid to a mere canine. This face is nearly circular in outline, the widening of the lateral surfaces by the spreading of the marginal ridges (*f, f*) adding to the width. The buccal cusp (*g*) is large and prominent, and is also drawn toward the centre of the tooth to accommodate the occlusion. Sometimes it is high and sharp when the lingual cusp is reduced, and is low and blunt when the latter is enlarged—appearing to have an inverse ratio in size to the inner cusp. The lingual tubercle or cingule varies much in size, from a mere point on the basal ridge, above the cervical border, to a pronounced cingule, a larger cingule, a small cusp, then a full cusp, the basal ridge (*h*) being raised with it. The ridges are the mesial and distal marginal ridges (*i, i*), which are bowed out round and full and are always pronounced; the buccal marginal ridges (*f, f*), leading down from the buccal cusp to form an angle with the mesial and distal marginal ridges; the basal ridge, when the lingual cingule is lowered (*b*); and the triangular ridge of the buccal cusp, which is always large, and when the inner tubercle is reduced leads down as a high central eminence. The lingual cingule, as a rule, possesses no triangular ridge.

The central groove usually crosses the central ridge (*k*), but not always, being often bowed around its lower termination. Sometimes the ridge is crossed by a sulcus. The groove terminates in a sulcus at each end, with slight triangular grooves branching up on the buccal cusp.

The *neck* is usually oval on section, being much constricted, the crown

flaring upward from the cervical portion, giving the crown the well-known bell shape. The enamel line dips but slightly, being usually level on all four sides. The buccal border sometimes presents a prominent ridge.

The *root* is single, long, tapering, and may be nearly round, but is usually flattened mesio-distally. It is sometimes thick the greater part of its length, and terminates in an abrupt, round, blunt apex (*c*, *d*). It is very liable to be crooked. It is rarely bifurcated and does not present grooves on its lateral faces.

The *pulp canal* is constricted and flattened at the neck, and the backward inclination of the teeth makes it difficult to enter. The possibility of the root being crooked and the peculiarity of its anatomical relationships[1] also increase the uncertainty of treatment, which makes the pulp canals of the lower bicuspids difficult to deal with.

The **lower second bicuspid** approximates the first on its distal side. It resembles the first as regards the general form of the crown, its tapering bell shape, the constriction of the neck, and the shape of the root. In all these features there is little difference between these teeth, and the description of the first will apply also to the second bicuspid.



FIG. 20

The morsal surface of the lower second bicuspid.

The *morsal surface* (Fig. 20), however, differs very materially from that of the first. This is circular in outline like the first, and the buccal cusp is full and rounded (*a*), but the inner cusp is divided by a groove (*b*) running over it, into two parts, so that it is really divided into two tubercles. This makes the lower second bicuspid in its typal form a tricuspid tooth, so that it differs from the lower first, which has but one cusp, and from the others, which have but two cusps. The lingual tubercles vary much in size, so that one may be suppressed and the tooth seem a bicuspid. The mesial lingual tubercle (*c*) may be of large size and be developed at the expense of the distal (*d*); this may be a mere cingule on the distal marginal ridge and appear on the distal side, but it is always present.

The morsal groove is (*e*) triangular in design, passing between each of the three tubercles. A well-marked triangular ridge descends from each of the cusps.

The tricuspid form of the morsal surface of this tooth is, of course, a reproduction of the trituberculate premolars of the lower primates, and of still lower mammals, although the triangular form of the crown is lost in man.

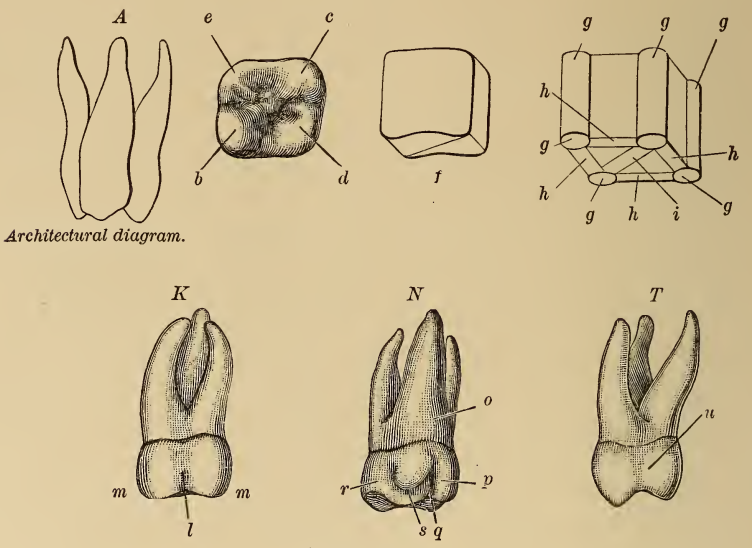
The Molars.—The molars in man are twelve in number, three on each side of each jaw, and are placed at the rear of the arch, opposite the strong

[1] See Chapter on Extraction of Teeth.

triturating muscles, for the purpose of crushing and masticating food. They are important factors in alimentation and contribute to the function of digestion by preparing food for the stomach. Their loss impairs this function seriously and leads to derangement of the stomach by overtaxing it with imperfectly masticated food substances.

The Upper Molar.—The typical upper molar is formed by the fusion of three cones, as is plainly observed in the three roots and the three tubercles (Fig. 21, *A*). The tricuspid molar, therefore, is a primitive form, and is rarely seen in man, the normal form being quadritubercular. The fourth additional cusp, the disto-lingual (*b*), is merely a supplemental cusp added to the crown. An upper molar is, therefore, composed of three tubercles, and a cingule which has not yet developed

FIG. 21



Architectural diagram.

The upper molar.

a root to support it. The tritubercular molar is the primitive form of this tooth, the quadritubercular appearing later, and is found in only a few living forms, as some of the lemurs and the insectivorous and carnivorous mammalia. In man there is sometimes a reversion of the upper molar to the tritubercular form, which is a marked degeneracy in the form of this tooth. In an analysis of this tooth, therefore, the mesio-buccal tubercle (*c*) is the canine cusp; the mesio-lingual, the biscuspid cusp (*d*); the disto-buccal, the molar cusp (*e*), and the disto-lingual is but a supplemental cusp—it is not a true cusp, as it has no root to support it.

The *architecture of the upper molar* presents some interesting features. We observe that the crown is in a general way a geometrical form, a cube (*f*), when perfect and symmetrical. It is suggestive of symmetry,

but when taken with the root form is not quite perfect, for it is supported on three roots instead of four to correspond with the four tubercles at the four corners. So it lacks the "harmony of adequate support," which is a cardinal principle in architecture. But the crown separately is a symmetrical form, a cube, although the angles are rounded off and the corners and points are toned down and not acute. We notice that there are four strong columns, one at each of the four corners (*g*). They are connected on the four sides by the marginal ridges acting as strong connecting arches (*h*). These arches are related to the columns of the crown, and both are impressively proportioned. The cusps may be likened to the capitals of the columns, and the descending marginal and triangular ridges to the cornice, gathered together to form the capitals. The triangular ridges may be considered girders (*i*), binding the four together and also bracing the square obliquely. Or, the four triangular ridges running to the centre may be regarded as half-arches or buttresses, supporting the roof vault,—the grinding face. Other elements could be marked out in an architectural study of the crown of this tooth, showing its beautiful design and symmetry.

The **upper first molar** approximates the second bicuspid on its distal side. There is a marked and abrupt change in form, as the molar has double the number of cusps of the bicuspid—being formed like two bicuspids fused together. The four tubercles constitute an extension of surface and a further adaptation to functional requirements. The crown is large and cubical in form, and more or less rounded.

The *buccal face* (*K*) is wide and rounded. It is twice the width of the bicuspids. It is broadest at the morsal margin, narrowing upward to the cervix, where it is widely rounded or arched. A vertical depression, the buccal groove (*l*), extends from the cervical border to the morsal margin, dividing the face into two oblong rounded eminences, the mesial and distal *buccal lobes* (*m m*).

The *lingual face* (*N*) is more rounded than the buccal, the cervical portion being the most convex (*o*), the mesial and distal sides being depressed toward the single lingual root. The morsal half is divided by the lingual groove (*q*), which descends over the lingual marginal ridge between two lobes, the mesial (*r*) and distal (*p*), which are usually much rounded. The morsal half of the face curves toward the grinding surface. The mesial lobe sometimes presents the lingual cingule (*s*), a sort of fifth tubercle of greater or less size. A groove branches from the lingual groove and extends over, between the cingule and crown.

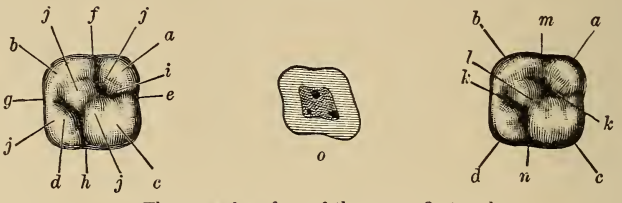
The *mesial face* (*T*) is flat longitudinally, descending from the marginal ridge to the cervix in a nearly straight line. Bucco-lingually it is convex, nearly flat at the marginal ridge, and rounded at the cervix, being depressed toward the lingual root. Sometimes a depression from the bifurcation of the mesio-buccal and lingual roots extends part way up on the face (*u*).

The *distal face* is similar to the mesial except that it dips more toward the cervix, and is, perhaps, more rounded toward the lingual root.

The *morsal surface* (Fig. 22) is the most important part of this tooth, and shows features that make it interesting and unique. The abrupt change from the bicuspid form is notable, for there are presented four cusps, a doubling of the number; the outline of this face presents a square form with tubercles at each corner, the mesio-buccal (*a*), the disto-buccal (*b*), the mesio-lingual (*c*), and the disto-lingual (*d*); the latter is erratic and may be either pronounced or quite reduced in size.

There are four marginal ridges: the mesial (*e*), buccal (*f*), distal (*g*), lingual (*h*), the oblique (*i*), and the four triangular ridges (*j*). The oblique ridge connects the mesio-lingual with the disto-buccal tubercle and is really the remnant of the marginal ridge of the tricuspid molar; the fourth cusp, the disto-lingual, being raised up on the disto-lingual side. The four triangular ridges descend from the four tubercles toward the centre of the tooth, the oblique ridge being formed by the fusion of the triangular ridges of the mesio-lingual and disto-buccal cusps.

Fig. 22



The morsal surface of the upper first molar.

There are two fossæ (*k*), one mesial and the other distal to the oblique ridge. Sometimes the latter is cut by a groove or sulcus (*l*) which extends from the mesial to the distal fossa. Sometimes by the reduction of the disto-lingual lobe and cusp, the mesial fossa is extended and becomes central to the crown. A groove extends from the mesial fossa over the buccal marginal ridge (*m*) quite on to the buccal face, dividing the mesial from the distal buccal lobes. A groove also extends over the lingual marginal ridge (*n*) down upon the lingual face, dividing the lingual lobes. When this groove becomes a fissure and caries ensues the disto-lingual cingule readily breaks away, this cingule being a weak feature in the mechanical design of this tooth; cutting the distal marginal ridge also weakens this cusp. The triangular grooves branch from the two fossæ on to the cusps, dividing the triangular from the marginal ridges.

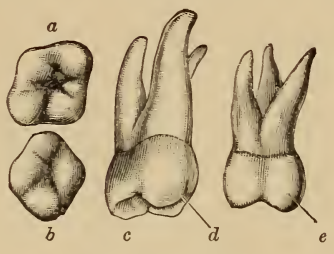
The *neck* of this tooth is of rounded rhomboid form on section (*o*), widest at the buccal side. The enamel is almost level on all four sides, dipping downward slightly on the mesial and distal. A depression occurs at the bifurcation of the buccal roots, and an inward inclination on the mesial and distal sides.

The *roots* are three in number (Fig. 21), two on the buccal side, which are small and flat or round, and one on the lingual side, which is large and rounded. The roots are usually separated, but may be found united, by a septum of cementum, in various directions. The mesio-buccal root is the larger of the two buccal roots, and forms a second turning-point or spring of the arch. All the roots are slightly bent and may be very crooked.

The *pulp chamber* branches into three canals, one in each root. The lingual canal is large and open and is readily entered. The canals of the two buccal roots are small and fine, and, with the possibility of crookedness in the roots, present the most difficult problems as to treating and filling found in the whole denture.

The **upper second molar** is similar to the first in some respects, but very different in others. It is rather smaller, is not usually full and square, but disposed to become rhomboid in form (Fig. 23, *a*, *b*), by disto-mesial compression.

Fig. 23



The upper second molar.

The *buccal face* is similar to that of the first molar, and the same description will apply to it. If any difference is found it is that the face is strongly compressed from front to back, and the disto-lingual cusp is more reduced as a constant feature.

The *lingual face* (*c*) is different from that of the first molar in that by the suppression of the disto-lingual tubercle (*d*) and the distal lobe the mesio-lingual lobe is enlarged so that it occupies the entire face, which is full, rounded, and convex (*e*). It is rarely divided into two lobes, as in the first molar, owing to the enlargement of the mesial lobe and the pushing backward of the oblique ridge, which throws the lingual groove on to the distal lingual angle (*d*); or the groove may be absent altogether.

The *mesial* and *distal* faces are similar in form to those of the first molar, being perhaps more flattened.

The *morsal face* is similar to that of the first molar, except that the tubercles are less pronounced and the distal ones are reduced in height to accommodate the upward curve of the line of occlusion at this point. The disto-lingual cingule is smaller than that upon the first molar, and is often barely marked. This throws the oblique ridge more to the distal side and enlarges the mesial fossa. The various grooves are the same as on the first molar, except that one, the lingual, may be lost.

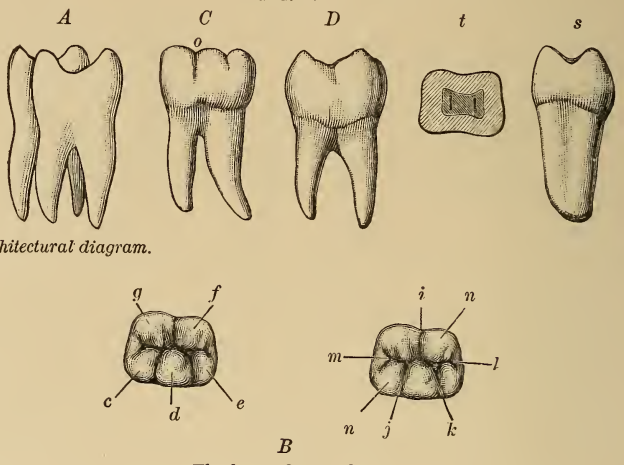
The *neck* is less regular in outline than that of the first molar, as the crown varies so much in shape. It is more flattened mesio-distally and depressed toward the roots.

The *roots* are the same in number and general form as in the first

molar, but spread less and are more irregular in form. They may converge or be crooked, or may be fused together. This makes the pulp canals more difficult to treat. Sometimes the three roots are completely fused, as in the third molar, and the canals may coalesce; or the canals of the two buccal roots may run into one. The irregularity and uncertainty of the form of the roots make this tooth difficult to deal with in treating its pulp canals.

The Lower Molars.—The **lower first molar** approximates the lower second bicuspid on its distal side. It is the first of the true grinders of the lower jaw and the largest tooth in the dental series. Unlike the upper molars the transverse diameter is less than the mesio-distal. The greater width is found across the base of the disto-buccal tubercle. The crown is square or trapezoidal in form, depending on the size of the fifth tubercle. Being quinquetuberculate, the crown is broadened by the multicuspid grinding face. The buccal face is inclined toward the centre of the tooth, for its morsal half, to accommodate the occluding teeth.

FIG. 24



The lower first molar.

Architecturally, the tooth is formed of four cones (Fig. 24, *A*), and may be roughly divided into four quarters. There are four primitive cones with their tubercles and one cingule in the structure.

The *morsal* surface (*B*) is trapezoidal in outline, the buccal line being the longest. The buccal angles are acute, while the lingual are rounded and obtuse.

There are five *tubercles*, two on the lingual margin and three on the buccal. They are named the mesio-buccal (*c*), median buccal (*d*), disto-buccal (*e*), disto-lingual (*f*), and mesio-lingual (*g*). These tubercles are less obtuse and more rounded than those of the other grinding teeth, the mesio-buccal usually being the largest; the others are not so prominent, rarely raised and sharp.

The *ridges* are: the marginal ridges—buccal, distal, lingual, and mesial—and the five triangular ridges descending from the five tubercles toward the centre of the tooth.

The *grooves* and *sulci* upon the morsal surface are very irregular. A deep sulcus traverses the face from the mesial to the distal marginal ridge. A groove runs off toward the lingual side, dividing the lingual cusps (*i*), sometimes cutting the lingual marginal ridge, but rarely reaching over on the lingual face. A groove runs toward the buccal side, dividing the mesio-buccal from the median tubercle (*j*), cutting the marginal ridge and extending over quite on to the buccal face. This groove often becomes the seat of caries, owing to the enamel structure being faulty. Another groove extends toward the disto-buccal angle (*k*), dividing the median from the disto-buccal tubercle, and rarely extends over on to the buccal face. A groove may extend distally, cutting the distal marginal ridge (*l*), and one mesially, cutting the mesial marginal ridge (*m*), but these are not usually marked. The triangular groove running up on each side of the triangular ridges (*n*) divides these from the marginal ridges. Supplemental grooves may divide the triangular ridges again. The pits at either end of the sulcus may become the seat of caries through faulty formation.

The *buccal face* (*C*) is an irregular trapezoid in form, the morsal margin being longest; the mesial and distal sides converge toward the cervical border, which is rounded. The morsal margin is broken by the three tubercles rising upon it. The buccal face is convex in all directions, that from the morsal to the cervical borders being the most marked, owing to the morsal half converging toward the centre of the tooth. The buccal groove (*o*) leading over from the morsal face divides the face into two lobes, which are full and rounded. Sometimes the disto-buccal groove cuts off another lobe, thus making three lobes on the buccal face. These grooves sometimes lead to the cervical border, but usually terminate in the middle of the face in a pit, which may become the seat of caries through faulty formation of the enamel.

The *lingual face* (*D*) is wide, rounded, smooth, and convex, rather straight perpendicularly, leaning in the lingual direction. It forms a sharp angle with the morsal surface, which is surmounted with two tubercles. Sometimes, but rarely, the lingual groove passes over on to this face.

The *mesial* and *distal faces* (*s*) are wide and flattened transversely, but convex vertically. They are trapezoidal in outline, the morsal border being longer. The cervical border is more convex, and dips toward the neck of the tooth.

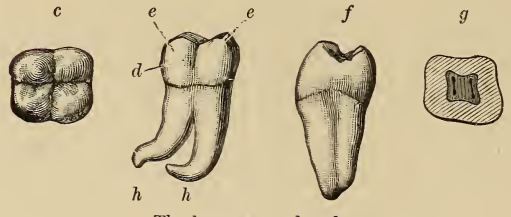
The *neck* (*t*) is very regular in outline and contour. It is approximately square with all four sides depressed in the centres. The mesial and distal are depressed at the origins of the grooves leading down upon the roots; the lingual and buccal are depressed at the bifurcation

of the roots, the depression, which is wide and deep, extending up on to the neck, especially upon the buccal side. The enamel line is quite irregular, dipping down on the lingual and buccal, and leading well up on the mesial and distal sides.

The *roots* are two in number, placed with their longer diameter transversely to the jaw. They are wide bucco-lingually, and flat and narrow disto-mesially, being situated distally and mesially to the crown. The posterior is formed of the two posterior cones, and the anterior of the two anterior cones (*A*). This is plainly shown in the formation of the roots, which are grooved both distally and mesially, and in the tendency to bifurcation, which sometimes actually occurs. They divide close to the crown, so that the grooves of bifurcation extend well up on the neck. The distal root is thicker and more rounded than the mesial, the latter being more flattened, with the grooves deeper, and it is more often bifurcated. Both are deflected from the median line.

The *pulp canal* is shaped like the roots, with two main branches. The distal branch is the larger, being round and open, as the root is more rounded. The mesial branch is flat and spindle-shaped, being difficult to enter, and usually having two sub-branches, following the buccal and lingual divisions of the root. These sub-branches are small and hair-like and troublesome to enter.

FIG. 25



The lower second molar.

The **lower second molar** (Fig. 25) differs from the first in many respects. It is of the same general form, but is more quadrangular, as it has but four tubercles. It is more rounded and symmetrical than the first, the four cones and four primitive tubercles being well marked. The absence of the fifth tubercle leads to most of the differences between the second and the first molar.

The *morsal face* (*c*) has but four tubercles, one at each corner of the face, differing from that of the first molar, which has five. The fifth tubercle rarely appears in the higher races of mankind, but is sometimes found in the low savage races, and occurs regularly in the apes. It is not uncommon in the negro, but is absent, as a rule, in the European races. The tubercles are symmetrical, rounded and obtuse, the lingual being, however, sharper than the buccal.

The *sulci* describe a cruciform shape, separating the four tubercles symmetrically from each other. The buccal groove sometimes continues on to the buccal face, rarely to the lingual. The triangular grooves run up on the morsal triangular ridges. The marginal ridges are well marked, the mesial and distal being often divided by grooves. The

triangular ridges are usually well marked, leading to the centre of the tooth. They are full and strong.

The *buccal face* (*d*) is convex and of more regular form than that of the first molar. It is divided into lobes (*e*, *e*) by the buccal groove (*d*), which is rarely deep. A pit is often found in the centre of the face, which may become the seat of caries. The face is curved toward the centre of the tooth, as in the first molar.

The *lingual face* is similar to that of the first molar, but may be more rounded toward the morsal border. It is symmetrically convex in both directions.

The *mesial* and *distal faces* (*f*) are similar to those of the first molar, except that, the crown being smaller, they may be more perpendicular, but are well rounded.

The *neck* (*g*) is more regularly formed than that of the first molar, the margin of the enamel line being quite as irregular. It may be more constricted.

The *roots* (*h*, *h*) are similar to those of the first molar, but are more rounded in shape, are usually crooked, and on that account difficult to treat.

The *pulp canals* are similar to those of the first molar, but the tendency to crookedness renders treatment quite difficult. The direction of irregularity of form is so uncertain that no rule can be applied to it.

The Third Molars.—The upper and lower third molars can best be described together, on account of their similar eccentricities. They are very irregular as to the time and to the frequency of their appearance in civilized man. About one-half of the individuals of European races erupt them at the normal period, *i. e.*, seventeen to twenty-one years of age. In one-fourth they erupt at irregular intervals to the thirtieth year, and in the remainder they may appear later, or the first, second, third, or all of them, may be absent altogether. In one series of forty adult skulls observed, twelve had one or more absent. The absence and other erratic peculiarities of these teeth sometimes seem to be hereditary, and can be traced in families through several generations.

The tooth is often reduced in size and may be a mere peg (Fig. 26, *a*). It is of very irregular form in civilized races, but is as large and as well formed as the other molars in most races low in the ethnological scale. The contraction of the jaws through disuse has much to do with the maldevelopment of this tooth, and it is often so cramped for room as to produce distressing irritation which necessitates its removal. Impaction and malposition of the third molars render them difficult of extraction and are the fruitful source of many serious lesions. (See the chapter on Extraction of Teeth.)

The **upper third molar** is more or less similar to the other upper molars when perfect and well developed, but it is very erratic as to form and structure.

This tooth, when well formed, is of trituberculate form (*b*), the disto-lingual cingule being suppressed. This cingule diminishes gradually from the first molar, in which it is well formed, to the second, where it is reduced, then to the third, where it is almost or entirely absent. The oblique ridge becomes the posterior marginal ridge (*c*), as in the typical trituberculate molar. The three tubercles are reduced and rounded. The sulci usually degenerate into fissures, as the formation of this tooth is notoriously faulty. The enlarged mesial fissures thus become the seat of extensive caries.

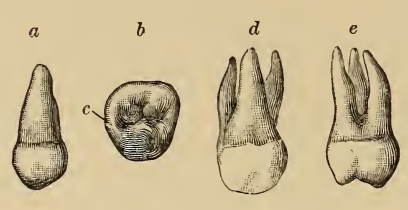
The *buccal face* resembles that of the first and second molars, but is more rounded.

The *lingual face* (*d*) is full and rounded, with but a single lobe, owing to the reduction or absence of the disto-lingual tubercle.

The *mesial face* (*e*) is similar to that of the second molar, but reduced, and the *distal face* is round and short, as no tooth succeeds it in the rear.

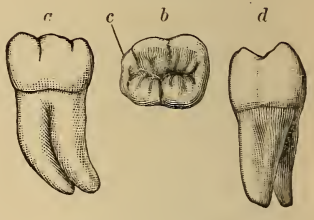
The *neck* is constricted and tapers toward the conate roots. It is of a rather rounded triangular shape.

FIG. 26



The upper third molar

FIG. 27



The lower third molar.

The three *roots* of the upper molars are, in the third, usually more blunt, conate, short in form, and may curve backward. In lower races and sometimes in individuals having strong osseous organizations, the typical three molar roots are found. Sometimes there are multiple roots, which are likely to be curved in various directions, and may have decided hooks.

In the large conate root the *pulp canals* usually coalesce, but in cases in which the root is divided there will also be division of the pulp chamber.

The **lower third molar** is similar to the other lower molars in general form (Fig. 27, *a*), but is probably not so erratic and not subject to such extreme variations. The crown is quadrangular in section, the angles rounded.

On the *morsal face* (*b*) there are four principal tubercles, as in the second molar, but this may be supplemented by the extension of the disto-marginal ridge into a cingule or heel (*c*). This heel is rather erratic; it may be large or small, thus modifying the size of the morsal surface. Sometimes the face is wrinkled and, like this tooth in the orang-outang, the sulci exhibit the cruciform shape similar to that of the

second molar. The many grooves leading away from the main sulcus may be imperfect and become the seat of caries. The buccal groove running from the morsal on to the buccal face (*a*) is very subject to imperfection.

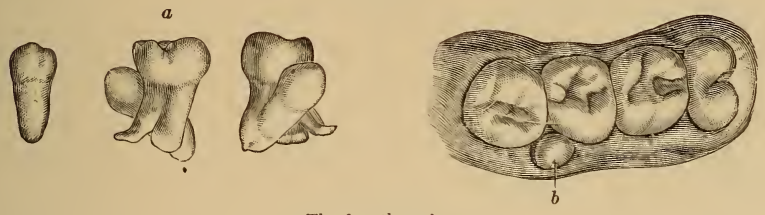
The four *lateral faces* are similar to those of the second molar, except that the distal is more convex and full, and often very prominent if the fifth cingule is well developed.

The *neck* is of similar shape to that of the second molar.

The *roots* are similar to those of the other lower molars, but generally smaller as compared with the crown (*d*). They are usually divided like the others, but the two may be fused together, or be closely opposed. In either case they are usually projected distally more or less, leading backward into and under the ramus, thereby rendering extraction of this tooth difficult and dangerous, especially where the maxilla is of dense structure or where there is impaction. The roots are usually more rounded, especially the distal one, than those of the other molars.

The *pulp canals* are generally divided, whether the root is or not. As the roots are usually crooked, the difficulty of entering them is increased as the canals follow the form of the roots.

FIG. 28



The fourth molar.

Fourth molars sometimes appear as supernumerary teeth, and are either fused to the upper third molar in a variety of uncouth forms (Fig. 28, *a*) or erupt separately as mere peg-shaped teeth between the buccal faces of the second and third molars (*b*) or at the distal aspect of the 'atter tooth. The fourth molar rarely appears as a full molar, except in some of the large-toothed races, as negroes, Australians, etc., and then usually in the lower jaw. Among the negroes in Africa the fourth molar is sometimes found in full form as a typical molar.

The tuberculate teeth, the bicuspids and molars, present many points of mechanical structure, with reference to operations upon them, that are of interest and importance. Beginning with the upper bicuspid, we find that being composed of two cones cemented together longitudinally, it is essentially a weak tooth. The triangular ridges being imperfectly fused at the transverse sulcus (indeed, this point is often the seat of a congenital fissure), the cusps are unsupported. The main dependence of the two cones for union and binding together is the power

of the marginal ridges, and when these are destroyed the crown readily splits, the buccal or lingual cusp breaking away with the wedging and force of mastication. When from extensive caries the approximal faces are destroyed and an elaborate compound filling is necessary, the lingual cusp, the one that most frequently splits off, should be reduced by grinding, so as to lessen the danger from wedging food. While pressure fillings are, of course, dangerous, there is also danger from inlays by reason of the too extensive cutting out of the sulcus and consequent weakening of the cusps. There should be as little transverse cutting as possible in order to guard this weak point in these teeth.

In the lower bicuspids the same conditions do not obtain, as their architecture and mechanical structure are entirely different. In the lower first bicuspid the transverse ridge is strong and well fused, so that the splitting off of either cusp is very rare. The second bicuspid is also of stronger mechanical structure. The weak point in both these teeth is the marginal ridge, which, by reason of the bell-shaped, tapering crown is not well supported, and if undermined, readily chips off. Therefore, approximal fillings on these teeth should be well anchored on the morsal surface and undercuts avoided. Attention must also be given to the lingual occlusion of these teeth, which increases the stress upon all operations upon them.

FIG. 29



Negro top jaw with fourth molar.

The upper molars are of beautiful and wonderful architecture, as before described, and present an interesting study. The greatest point of weakness in these teeth is the disto-lingual cusp, the hypocone, which often breaks away when undermined by distal caries, as the fusion with the oblique ridge and the protocone is weak. This should be obviated, after filling, by grinding down the point of the cusp. It is dangerous to cut the oblique ridge, for when the marginal ridges are destroyed it becomes the main binding girder of the crown. When this is undermined by caries the crown becomes so weakened that it readily splits. The introduction of the inlay, however, has greatly lessened the mechanical dangers of operating upon these teeth that cannot be avoided with the pressure fillings. Mesial inlays should, of course, be carried into the mesial sulcus and the buccal border preserved as much as possible for the esthetic effect. Indeed, extensive caries on this tooth can be better treated with the inlay than with the shell crown, and the natural crown be better preserved.

The lower molar is different from the upper in its mechanical design, and the lingual occlusion presents different problems. In the evolution

of its crown it will be remembered that the protoconid shifts to the buccal side and becomes the mesio-buccal cusp. The triangle of the lower molar is just the opposite, therefore, of the upper and carries two cusps, the two mesial, the third having been lost in the process of evolution. The talonid, therefore, supports three cusps, the two distal buccal and the disto-lingual, which are, therefore, weaker than those of the trigonid. Hence we have more breakdowns of the distal half of the lower molars than of the mesial. This must be considered in operating on this tooth, not making deep undercuts to weaken the cones, but depending upon occlusal retention. The cutting of the transverse ridges does not weaken the crown except when the cones are separated too deeply, which results in the splitting off of the lingual half of the crown, which is not uncommon. So the grinding of the lingual cusps must again be resorted to to prevent the danger of the wedging of food. The crown of the lower molar is essentially weak and the conservation of its weakest points, the junction of the cones, must be considered at all times. A knowledge of this weakness is obtained by a study of the evolution of the crowns of the molars.

The mechanical resistance of the molars, as well as their effectiveness in the mastication of food, depends much upon the accuracy of their occlusion. It is needless to say that this very rarely obtains in ordinary dentures. Malposition, extractions, abrasion, dental mutilations, imperfect and indolent use in the performance of the function of mastication, all contribute to the malocclusion of the molars which is so prevalent. Imperfect occlusion is productive of abnormal stress upon various parts of the crown and its consequent frequent breaking down along the lines of the junction of the cones. It follows, of course, that the proper procedure is to restore the normal occlusion as completely as possible by artificial means.

The Deciduous Teeth.—The deciduous teeth are those which appear in infancy and serve the purpose of dental organs during the first years of the development of the individual, until the jaws and their environment are ready for the larger, permanent teeth to come into place. They bear a direct relationship to the conditions of the digestive apparatus and the food required at that early stage. The food of infancy being simple and requiring little mastication, the deciduous set are small and insufficient for the reduction of more resisting substances. As these foods come to form part of the dietary, the larger teeth of the permanent set appear and perform the duties of higher functional activity.

The *crowns* of the deciduous teeth resemble, in a general way, those of the permanent teeth which succeed them, except the deciduous molars (Fig. 30, *a*, *d*), which are very different from the bicuspids of the permanent set which displace them.

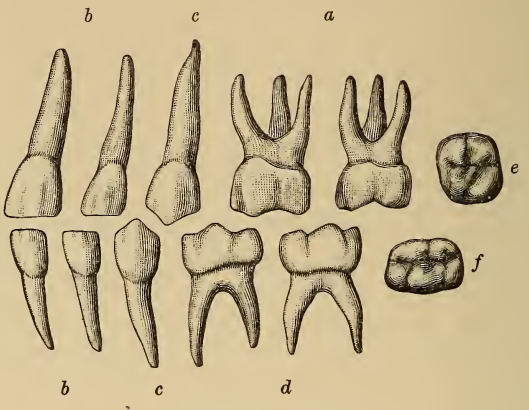
The **incisors** of both jaws precede the analogous teeth of the same series of the permanent set. They are similar in form, but reduced (*b*),

and do not have the main features so characteristically marked. They are infantile in form and function. The roots of these teeth are resorbed at from the fifth to the ninth year, when the permanent incisors come into place, beginning with the lower centrals.

The **cuspids** (*c*) of both jaws are still more reduced from the strong, full form of their permanent successors, and are but little more specialized than the incisors. They are of the same general form as the permanent cuspids, but much less developed.

But in the **deciduous molars** are found some important features which mark distinctive differences. They are of true molar form as compared with the permanent molars, but they occupy the place of the bicuspids. There are no bicuspids in the deciduous set, the molars being of full molar pattern (*a*, *d*).

FIG. 30



The deciduous teeth.

The deciduous molars of both jaws are of irregular, quadrangular form on the morsal surface, diverging rapidly outward to the neck, which presents a large buccal ridge standing out at the margin of the enamel, and is rounded off suddenly to the neck, which is much contracted. This thick ridge is characteristic of the deciduous molars and is absent in those of the permanent denture. It is somewhat more prominent and bulging on the buccal than on the other faces. In adjusting ferrule crowns to these teeth the gold need not be carried beyond this ridge, but burnished over it slightly.

The *morsal surface* (*e*) of the upper deciduous grinders presents the characteristic pattern of the upper molars, four tubercles, oblique ridges, etc., but reduced and contracted. A distinctive feature is that the marginal ridges and angles are more acute and sharp than in the permanent molars. Sometimes the two lingual cusps are reduced to one and the lingual border is rounded and crescentic.

The second molar is larger than the first and the morsal surface is wider.

The transverse diameter of the crowns of the upper molars is the longest.

The *lower molars* (*d*) are similar to the permanent molars in pattern, but are more irregular as to the contour of the morsal surface (*f*). The tubercles may be higher than in the upper molars, and the triangular ridges more marked. The central fossa may be large and wide, or divided by the triangular ridges. The second molar is five-lobed, unlike the second permanent molar, which has but four cusps. The morsal face is decidedly trapezoidal in outline, the mesio-distal diameter being greater than the transverse.

The *roots* of the deciduous molars are similar to those of the other molars, except that they are very divergent to accommodate the crown of the advancing bicuspids. They are thin and long, and difficult to enter and fill. The pulp chamber is large and open in the crown; as a consequence of this caries soon reaches the pulp. Treatment and filling of the canals is difficult and uncertain.

THE VARIATIONS OF TOOTH FORMS

The teeth *may vary quite extensively* from the typal forms which have been described, and these variations may be due to a number of causes. Through all degrees of variation, however, the type is still preserved, unless the tooth form is quite destroyed by pathological causes.

The general causes of variation may be enumerated as follows:

1. Incompleteness of development.
2. Reversion to primitive types.
3. Temperamental impress.
4. Pathological lesions.

1. Under **incompleteness of development** may be grouped all those varieties of stunted growth which are the effect of disuse and the consequent effort of Nature to reduce and suppress the teeth as useless parts. The third molar teeth suffer most from these suppressive attempts of Nature in the effort toward economy of growth; next to these teeth the upper lateral incisors are most frequently affected by reduction of size, stunted growth, and suppression. Other teeth are not affected, or but very slightly, by this influence, except in rare cases.

2. Under the second head, **reversion to primitive types,** we have a variety of interesting phenomena in the form of parts of the human teeth which seem to be a zoölogical legacy. These consist of conspicuous features which reappear and seem to recall forms of the teeth observed in some of the lower animal orders, especially the quadrumana and insectivora.

Among these features may be mentioned the curved upper central incisor with the prominent cingule on the lingual-buccal ridge, making a notch which recalls the incisors of the moles; the prominent cingule on the lingual face of the lateral incisor, which is not uncommon and recalls the form found in the insectivora and some of the quadrumana; the extra long, curved canine with extra large median ridges, which recalls the large forms of this tooth in the baboons and in the carnivora; the double root sometimes found in this tooth is also a reversion to the insectivorous type; the three-rooted bicuspid is a quadrumanous reversion; the upper tricuspid molar is a primitive typal form, leading back to the lemurs and beyond them to the early typal mammals found in fossil formations; the notched and grooved incisor recalls the divided incisor of the galeopithecus; the double-rooted lower incisors and canines recall insectivorous forms; the unicuspid lower first bicuspid is an insectivorous type and is often quite marked in man; the fifth cusp on the lower second molar is a quadrumanous reversion; the wrinkled surface of the lower third molar is like that of the orang, etc.

There are other features that might be named illustrating the workings of the *law of atavism*, by which parts once lost in evolution may reappear and be reproduced.

3. Under the third head, **temperamental impress,** may be noticed those differences of form and structure which have relation to the dominant temperament in the constitution of the individual. Great differences exist between the teeth of different persons, and these are mainly dictated by *temperament.*

The teeth of the *primary basal temperaments* present the following physical peculiarities, which are characteristic of the particular temperament:

The *bilious temperament* presents teeth that are of a strong yellow; large, long, and angular, often with transverse lines of formation, without brilliancy, transparency, and of but slight translucency; firm and close set, and well locked in articulation.

The *sanguine temperament* has teeth that are symmetrical and well proportioned, with curved or rounded outlines, and round cusps; cream color, inclined to yellow, rather brilliant and translucent; well set, and occlusion firm.

The *nervous temperament* has teeth which are rather long, the cutting edges and cusps long and fine; color pearl blue or gray, very transparent at the apex; the occlusion very penetrating.

The *lymphatic temperament* presents teeth that are pallid or opaque, dull or muddy in coloring; large, broad, ill shaped, cusps low and rounded; the occlusion loose and flat.

Of the *binary combinations:*

The *sanguineo-bilious* has teeth which are large, with strong edges and large cusps; color dark yellow, and quality good.

The *nervo-bilious* has teeth that are long and narrow, with long cusps; color yellowish or bluish, or both combined; the enamel strong, the dentin soft.

The *lympho-bilious* has teeth that are large, with thick edges and short thick cusps; yellowish in color; enamel of good structure and polish, and dentin fair.

The *bilio-sanguineous* has teeth of average size, round arch, well-developed cusps and edges; rich dark-cream color; excellent in quality.

The *nervo-sanguineous* has teeth of average size, good shape, round arch, good edges and cusps; rich cream color; enamel and dentin of excellent structure.

The *lympho-sanguineous* has teeth of more than average size, shapely edges and cusps, rounded arch; color grayish cream; enamel and dentin fairly good.

The *bilio-nervous* has teeth variable in size and form, sometimes broad, again very long with more pointed and long cusps; the color generally bluish; enamel fairly good, dentin soft and sensitive.

The *sanguineo-nervous* has teeth of average size, good shape, round arch; color grayish blue; soft and frail.

The *bilio-lymphatic* has teeth usually large, with thick edges, short, thick cusps, and flat arch; color yellowish; quality good.

The *sanguineo-lymphatic* has teeth of more than the average size, broad round arch; color gray; enamel and dentin poor.

The *nervo-lymphatic* has teeth of average size, good shape, average length, rather round arch; color bluish gray; soft and poor.

Combinations of the binary temperaments are of the most common occurrence in individuals, but there is usually one basal temperament that preponderates over the others and gives its characteristic to the teeth as a predominating influence.

4. Under the fourth head, **pathological lesions,** are to be included all those disturbances of nutrition which eventuate in faulty formation of the teeth, whether due to specific hereditary diseases, mere malnutrition, idiosyncrasies, predispositions, defective functional life, etc. But this leads beyond the province of this chapter into the field of special pathology and embryology.

CHAPTER II

DENTAL HISTOLOGY WITH REFERENCE TO OPERATIVE DENTISTRY.[1]

By FREDERICK B. NOYES, B.A., D.D.S.

The development of our knowledge of the cell has had a most profound effect upon the entire practice of medicine; in fact, the progress of modern medicine dates from the studies of cell biology, the germ theory of disease being only one of the phases of this development. In terms of the cell theory the functions of the body are but the manifest expression of the activities of thousands or millions of more or less independent but correlated centres of activity; if these centres or cells perform their functions correctly, the functions of the body are normal; but if they fail to perform their office, or work abnormally, the functions of the body are perverted. In the last analysis, then, all physiology is cell physiology; all pathology cell pathology. To modern medicine histology, or the cell structure of the organs and tissues of the body, together with cell physiology, is the rational foundation of all practice. This is as true for the dentist as for the physician so far as regards all of the soft tissues of the mouth and teeth that he is called upon to treat and handle. With caries of the teeth, the disease which most demands the attention of the dentist, the case is somewhat different. Caries of the teeth is an active destruction, by outside agencies, of formed materials which are the result of cell activity (the tissues themselves being passive). The cellular activities of organs and tissues of the body may have an influence, but this is only in producing those conditions of environment which render the activities of the destructive agents efficient in their action upon tooth tissues. Though the enamel and dentin are passive, we can understand the phenomena of caries only as we understand the structure of the tissues; and not only must the treatment of caries be based upon a knowledge of the structure of the tissues, but the mechanical execution of the treatment is facilitated by that knowledge. In the preparation of cavities the arrangement of the enamel wall is determined by our knowledge of the direction of enamel prisms in that locality, and to a certain extent the position of the cavity margins must be governed by our knowledge of the structure

[1] In the preparation of this material I am indebted to Dr. G. V. Black for the use of his large and valuable collection of microscopic slides, and for much advice and many suggestions.

of the enamel. In the execution of the work a minute knowledge of the direction of enamel rods becomes the most important element in rapidity and success of operation.

From the standpoint of comparative anatomy, the teeth are found to be not a part of the osseous system, but appendages of the skin, and are to be compared with such structures in the body as the nails and the hair. The teeth are a part of the exoskeleton, and their relation to the bones of the endoskeleton is entirely secondary, for the purpose of strength, the bone growing up around the tooth to support it.

If we examine the skin of such an animal as the shark, we find the entire surface covered with small calcified bodies which are really small simple cone-shaped teeth The mouth cavity is to be regarded,

Fig. 31



Shark's skull (Lamna cornubica), showing succession of teeth.

when viewed in the light of its development, as a part of the outside surface of the body which has been enclosed by the development of the neighboring parts, and the dermal scales or rudimentary teeth which were found in the skin covering the arches which form the jaws have undergone special development for the purposes of seizing and masticating the food. In the simplest forms there is only a development in size and shape of these scales, and they are supported only by the connective tissue which underlies the skin. These teeth are easily torn off in the attempt to hold a resisting prey, and, as in the shark, they are constantly being replaced by new ones (Fig. 31). In the more highly developed forms there is a growth of the bone of the arch forming the jaw upward around the bases of these scale-like teeth, to support them more firmly and render them more useful.

If we compare the structure of the hair with that of the tooth, we find, in the case of the hair, a horny structure composed of epithelial cells resting upon a papilla of connective tissue; in the case of the tooth, a calcified structure formed by epithelial cells resting upon a papilla of connective tissue which is also partially calcified.

The relation of the bones of the jaws to the teeth is entirely a secondary and transient one. The bone grows up around the roots of the teeth to support them, and is destroyed and removed with the loss of the teeth or the cessation of their function. In this way the development of the

FIG. 32



Changes in the mandible with age; buccal and lingual view.

alveolar process takes place around the temporary teeth; all of this bone surrounding their roots is absorbed and removed with the loss of the temporary dentition, and a new alveolar process grows up around the roots of the permanent teeth as they are formed. This development of bone around the roots of the teeth leads to the changes in the shape of the body of the lower jaw, increasing the thickness above the mental foramen and the inferior dental canal. When the teeth are finally lost this bone is again removed and the body of the jaw is reduced in thickness from above downward (Fig. 32). These phenomena are of importance in their bearing upon the causes and treatment of diseased conditions of the teeth, particularly those which involve the supporting tissues.

Dental Tissues.—The human teeth are made up of four tissues (Fig. 33):

1. The *enamel* covers the exposed portion of the tooth, or crown, and gives the detail of crown form. Its function is to protect the tooth against the wear of friction.

2. The *dentin* forms the mass of the tooth and determines its class form, the number of cusps and the number of roots being indicated by the dentin form.

3. *Cementum* covers the dentin beyond the border of the enamel, overlapping it slightly at the gingival line and forming the surface of the root. Its function is to furnish the attachment of the fibers of the peridental membrane, which fastens the tooth to the bone.

4. The *pulp*, or soft tissue, filling the central cavity in the dentin is the remains of the formative organ which has given rise to the dentin. Its functions are the formation of dentin and a sensory function.

In describing the structure of the teeth and the arrangement of the structural elements of the tissues directions are described with reference to three planes:

The mesio-disto-axial plane, a plane passing through the centre of the crown from mesial to distal and parallel with the long axis of the tooth.

The bucco-linguo-axial plane, a plane passing through the centre of the crown from buccal to lingual and parallel with the long axis of the tooth.

The horizontal plane, at right angles to the axial planes.

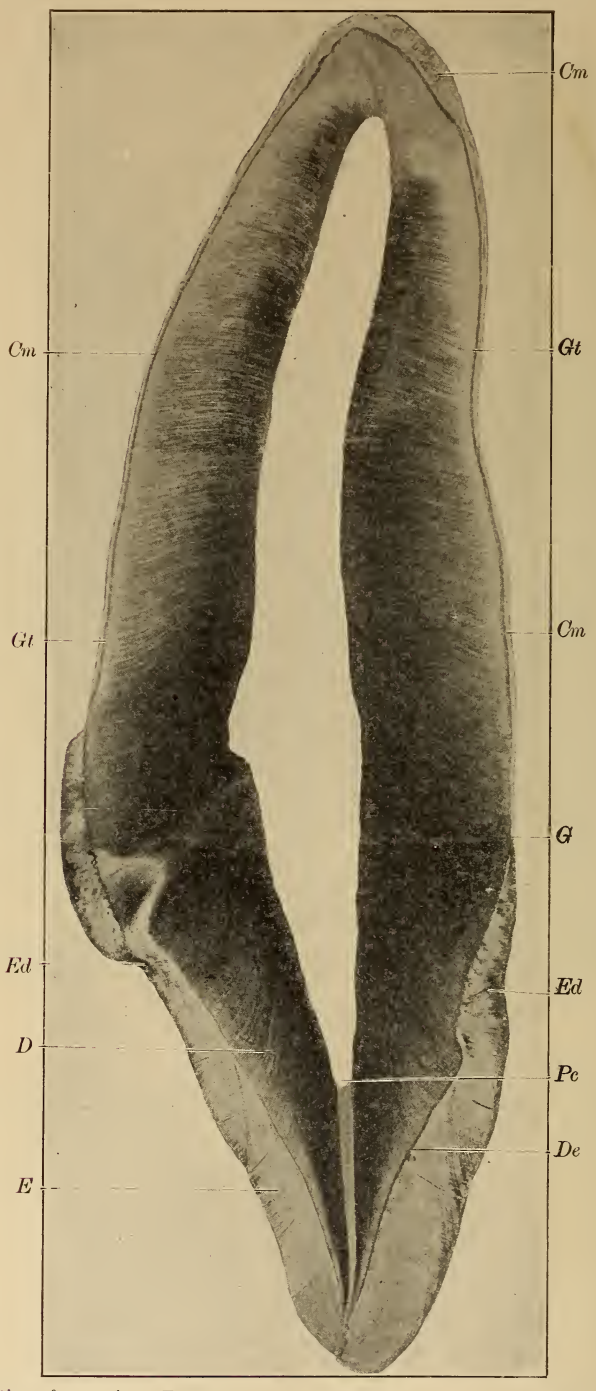
The Supporting Tissues.—The human teeth are supported on the maxillary bones, their alveolar processes growing up around the roots of the teeth, so that the roots fit into the holes in the bone. The calcified structures of the tooth and the bone are not, however, united, but the roots are surrounded by a fibrous membrane, the *peridental membrane*, or *pericementum*, which fastens the tooth to the bone.

ENAMEL

The enamel differs from all other calcified tissues in the nature of the structural elements of which this tissue is made up, in the degree of calcification, and in origin, being the only calcified tissue derived from the epiblast.

The enamel is formed from an epithelial organ derived from the epithelium of the mouth cavity and indirectly from the epiblastic germ layer, while all other calcified tissues are products of the mesoblast. In the case of bone and dentin the formative tissue is persistent. It is possible in bone at least, therefore, to have degenerative and regenerative changes, or the removal of part of the calcium salts and their replacement through the agency of the formative tissue; while in the

FIG. 33



Ground section of a canine: *E*, enamel; *Cm*, cementum; *D*, dentin; *Pc*, pulp chamber; *De*, dento-enamel junction; *Ed*, enamel defect; *G*, junction of enamel and cementum at the gingival line; *Gt*, granular layer of Tomes. (Reduced from photomicrograph made in three sections.)

enamel no such regenerative change is possible, as the formative tissue disappeared when the tissue was completed and before the eruption of the tooth.

The enamel is the hardest of human tissues. Chemically it is composed of the phosphates and carbonates of calcium and magnesium and a very small amount of the fluorides, water, also a very small amount of organic matter if any.[1] The enamel in the natural condition, bathed in the fluids of the mouth, contains a considerable amount of water. If dried at a little above the boiling point of water, it gives up part of it and shrinks considerably, so as to crack in fine checks. If heated almost to redness, it suddenly gives off from 3 to 5 per cent. (of the dry weight) of water with almost explosive violence. These facts were demonstrated some years ago by Charles Tomes,[2] and account for most of what was formerly recorded as organic matter in old analyses.

If we observe under the microscope the action of acids upon thin sections of enamel, when the inorganic salts are entirely removed, the structure of the tissue vanishes, there being no trace of organic matrix left as in the case of bone or dentin. In the growth of bone and dentin the formative tissue produces first an organic matrix in the form of the tissue, and into this the inorganic salts are deposited, combining with the organic substances of the matrix. This union is comparatively weak, however, for by the action of acids the combination is broken up and the inorganic salts are dissolved; or by heat the organic matter is removed, and in either case the form of the tissue will be maintained.

In the case of the enamel, the formative organ produces organic substances containing inorganic salts, and the substances are arranged in the form of the tissue after the manner of a matrix; but finally under the action of the formative organ all of the organic matter is removed and substituted by inorganic salts, whatever organic matter is found in the fully formed tissue being the result of imperfect execution of the plan.

The enamel is composed of two structural elements, the *enamel rods*, or prisms, sometimes called enamel fibers, and the *interprismatic* or *cementing substance*, both of which are calcified. It is to the arrangement of these structural elements that the characteristics of the tissue with which we are most concerned in operative procedures are due.

[1] Von Bibra gives the following analysis of enamel:

Calcium phosphate and fluorid	89.82
Calcium carbonate	4.37
Magnesium phosphate	1.34
Other salts	0.88
Cartilage	3.39
Fat	0.20
Total organic	3.59
Total inorganic	96.41

[2] Journal of Physiology, 1896.

While both the prisms and interprismatic substance of the enamel are calcified, or, better, composed of inorganic salts, the two substances—that is, the substance of the rods and the substance between the rods—show markedly different properties both chemical and physical. If treated with acid, the interprismatic substance is acted upon more rapidly than the rods, so that the latter become more conspicuous. By this means sections of the enamel may be etched to render it easier to study the direction and arrangement of the rods. If the action of the acid is carried far enough, the rods will fall apart before they are themselves entirely dissolved. Fig. 34 is from the debris in a carious cavity, and shows rods isolated by the action of the acids of caries.

Fig. 34



Enamel rods isolated by caries. (About 465 ×)

The interprismatic substance is not as strong as the rods, so that in splitting or breaking the enamel the tissue separates on the lines of the cementing substance, occasionally breaking across a few rods but following their general direction, the lines running between rods, not at their centres.

In cleaving the enamel the chisel does not enter the tissue separating rod from rod, but the edge engages with the surface, and the force applied at an acute angle with the direction of the rods fractures the tissue in the lines of least resistance. If the edge be keenly sharp, it will enter the tissue slightly, and then the bevel acts as a wedge in addition to the force applied to the shaft of the instrument; but if the edge be dull, it will rest across the ends of many rods, will not engage with the surface, and the force applied will break and crumble the tissue, but will not cleave it.

The enamel rods, or prisms, are long, slender prismatic rods or fibers, five- or six-sided, pointed at both ends, and alternately expanded and constricted throughout their length. They are from 3.4 to 4.5 microns[1] in diameter, some of them apparently reaching the entire distance from the surface of the dentin to the surface of the enamel; but as the diameter of the rods is the same at their outer and inner ends, and as the crown surface is much greater than the surface of dentin covered by enamel, there are many rods which do not extend through the entire thickness. These short rods end in tapering points between the converging rods which extend the entire distance. To express this in terms of development: as the formation of enamel begins at the surface of the dentin, the increasing area of crown surface requires more ameloblasts, and as new ameloblasts take their place in the layer the formation of new enamel rods begins between the rods which were previously forming. These short rods are most numerous over the marginal ridges and at the points of the cusps, and will be considered more fully in connection with those positions.

In ground sections cut at right angles to the direction of the rods[2] the tissue has the appearance of a mosaic floor, the outline of the rods being more distinct if they have been marked out by treating the section slightly with acid (Fig. 35). In longitudinal sections (Fig. 36) the sides of the rods are not smooth and even like the sides of a lead pencil, but are alternately expanded and constricted. They are well illustrated by taking balls of soft clay and sticking them together one above another to form a rod, then putting a number of rods together so that by mutual pressure they take hexagonal forms. This illustrates also the manner of growth of the tissue in formation. The expansions and constrictions can be seen in rods that have been scraped from a cleaved surface of enamel, but better by isolating rods by the slight action of dilute acid (Fig. 37).

In the construction of the tissue the rods are so arranged that the expansions of one rod come opposite to the expansions in the adjoining rods, and do not interlock with their constrictions. This arrangement leaves alternately a greater and a less amount of cementing substance between them.

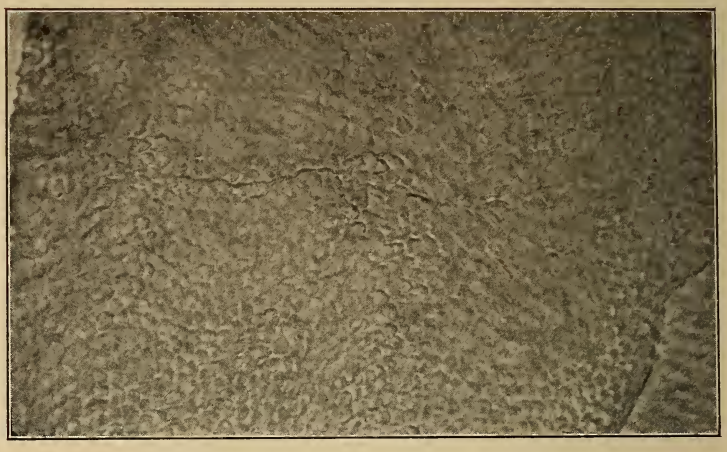
When observed under the microscope, the enamel rods show a characteristic appearance of light and dark lines running across them. These markings are similar to the striations of voluntary muscle fibers, and are described as the striation of the enamel. It is seen not only in isolated rods (Fig. 34), but also in sections ground in their direction (Fig. 38). This appearance of striation in the enamel is caused by the alter-

[1] A micron is the unit of microscopic measurement, and is equal to one one-thousandth of a millimeter.

[2] In describing the direction of enamel rods they are always considered as extending from the dentin to the surface, and the angle is formed at the surface of the dentin with the locating plane, either horizontal or axial.

nate expansions and constrictions of the rods refracting the light like a lens. In sections the expansions in adjoining rods are opposite to each

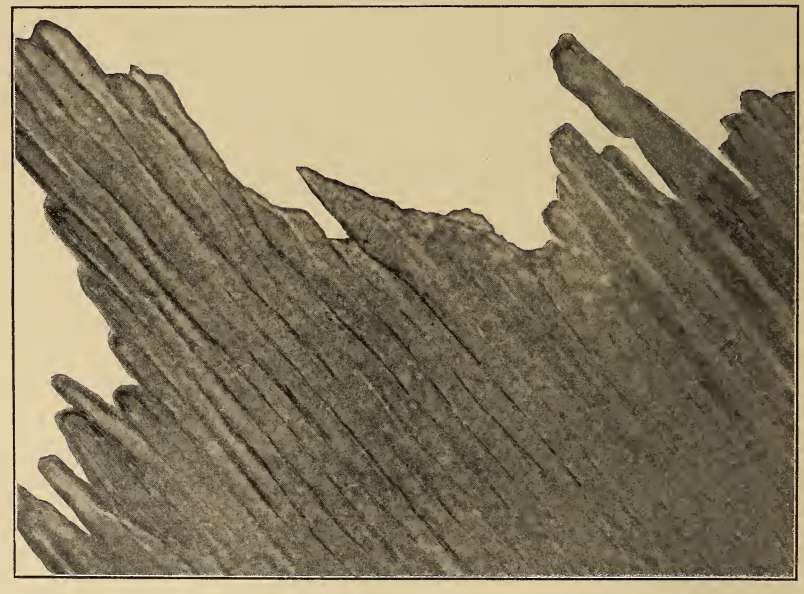
FIG. 35



Transverse section of enamel rods. (About 80 ×)

other, the difference in the refracting power of the prismatic and interprismatic substances producing the same effect.

FIG. 36

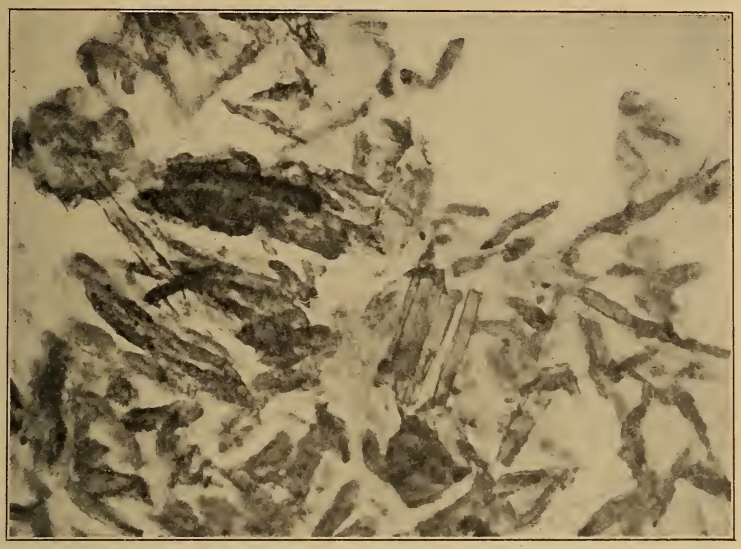


Enamel rods in thin etched section. (About 800 ×)

The appearance of striation is the record in the fully formed tissue of the manner of growth, each dark stripe, or expansion, in a rod repre-

senting a globule of partially calcified material. The ameloblasts build up the rods by the addition of globule after globule, surrounding

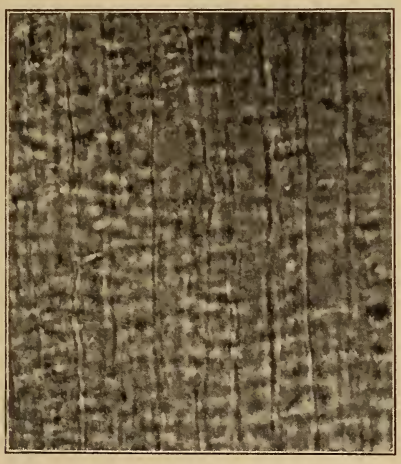
FIG. 37



Enamel rods isolated by scraping. (About 800 ×)

them with a cementing substance and completing the calcification of both. In this sense the striation of the enamel may be said to record the growth of the individual rods.

FIG. 38



Enamel showing striation. (About 1000 ×)

While the enamel is a very hard substance when its structure is complete and perfect, its most striking physical characteristic is a tendency

to split or crack in the direction of its structural elements when a break has been made in the tissue. While it is difficult to cut across the rods or make an opening on a perfect surface, if a break has been established it is comparatively easy to split off the tissue from the sides of the opening when the rods lie parallel with each other. Fig. 39 shows a field of enamel illustrating the way in which the tissue splits or cleaves in the direction of the rods.

Upon the axial surfaces the enamel rods are usually straight and parallel with each other, except where there has been some flaw or disturbance in development; but upon the occlusal surface, although sometimes straight, they are very often much twisted and wound around each other, especially at their inner ends. This difference in the arrange-

FIG. 39



Enamel showing direction of cleavage. (About 70×)

ment of the rods causes the greatest difference in the feeling of the tissue under cutting instruments. Such a specimen of enamel as shown in Fig. 40 can be cut away easily, the tissue breaking through to the dentin and splitting off in chunks; while a specimen like Figs. 41 and 42 will not cleave if supported upon sound dentin. If the outer ends of the rods are straight, they will split part way to the dentin (Fig. 42); but where they begin to twist around each other they will break across the rods. If the dentin is removed from under such enamel, it will break in an irregular way through the gnarled portion.

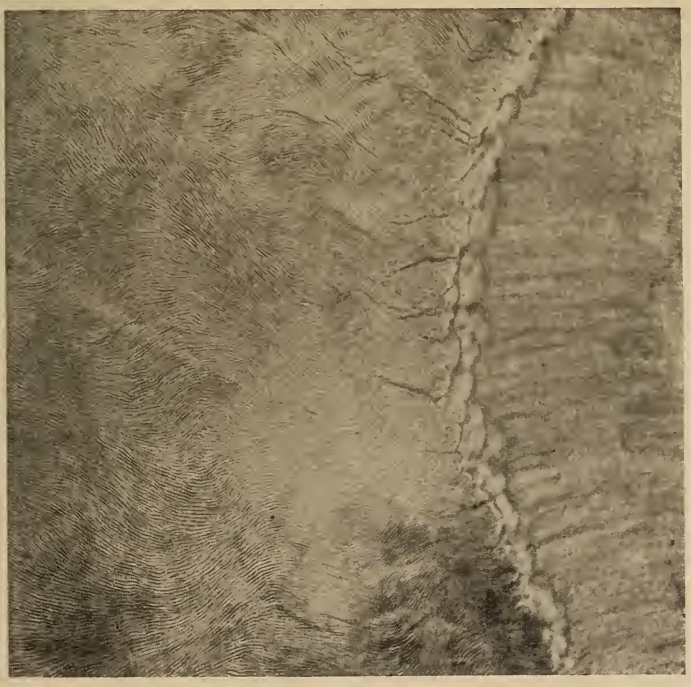
From a study of the arrangement of the enamel rods in the formation of the crown it is apparent that the plan is such as to give the greatest strength to the perfect structure, and may be likened to an arch. At the gingival border the rods are short and are inclined apically 6 to 10

FIG. 40



Straight enamel rods. (About 80 ×)

FIG. 41



Gnarled enamel. (About 80 ×)

centigrades[1] (20 to 35 degrees) from the horizontal plane. These short rods are overlapped for a short distance by the cementum. This inclination grows less and less, and at some place in the gingival half of the middle third of the surface they are in the horizontal plane. At this point they

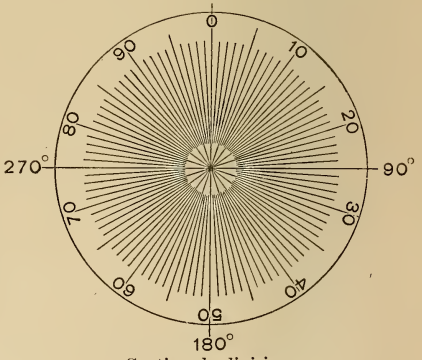
FIG. 42



Gnarled enamel. (About 50 ×)

are also usually perpendicular to the surface of the dentin. Passing from this point they become inclined more and more occlusally from the horizontal plane, at the junction of the occlusal and middle thirds about 8 to 12 centigrades (28 to 40 degrees) in bicuspids and molars, and 8 to 18 centigrades (28 to 65 degrees) in incisors and canines. In the occlusal third

[1] In the centigrade division the circle is divided into one hundred parts, each called a centigrade. One centigrade is equal to 3.6 degrees of the astronomical circle, 25 centigrades to 90 degrees, 12 centigrades to 45 degrees. The cut gives a comparison of the two systems of measuring angles.



Centigrade division.

the inclination increases rapidly, and often the outer ends of the rods are inclined more than the inner ends. Over the point of the cusps and the crest of the marginal ridges the rods reach the axial plane, though they are often very much twisted about each other in the inner half of their length. This position does not always correspond with the highest point of the cusp, but is inclined slightly axially from that position, and corresponds with the highest point of the dentin cusp.

Fig. 43

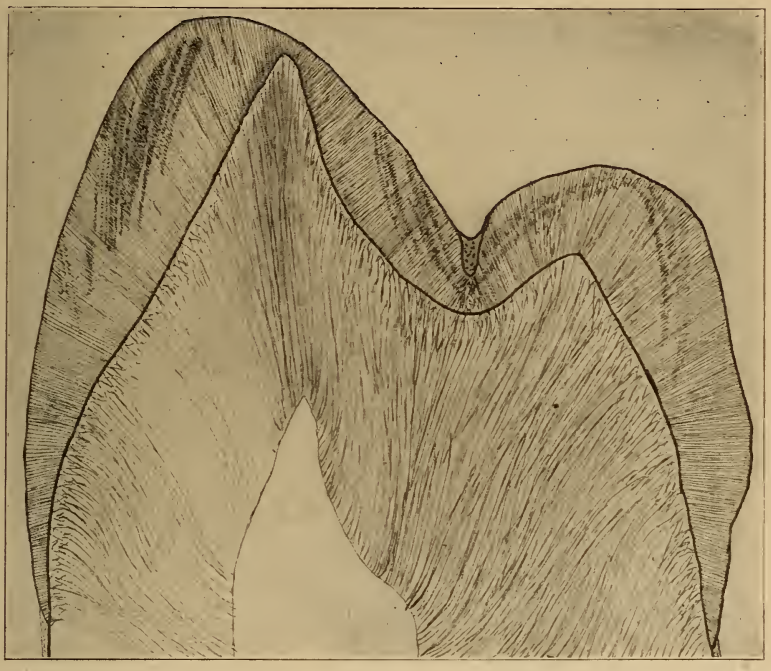


Diagram of enamel rod directions, from a photograph of a bucco-lingual section of an upper biscupid.

Passing down the central slope of the cusp, or ridge, the rods become again inclined away from the axial plane toward the groove, or pit, leaning toward each other where the two plates meet. The degree of inclination of the rods on the central slope of the cusps depends upon the height of the cusps; the higher the cusp the greater the inclination from the axial plane. Fig. 43, a diagram from a photograph of a bucco-lingual section of an upper bicuspid shows the plan of arrangement and illustrates the arch principle in the construction.

In the study of longitudinal sections of the teeth, one of the most conspicuous structural features is the stratification bands, or *brown bands of Retzius*. These bands are not parallel with either the outer surface of the enamel or the dento-enamel junction. They begin at the tip of the dentin cusps and sweep around in larger and larger zones.

These stratification bands are better seen in comparatively thick sections, and are caused by the varying amount of pigment deposited with the calcium salts in the development of the tissue. They record the growth of enamel of the crown as a whole, as each line was at one time the surface of the enamel cap. These stratifications, or, better, incremental lines, are shown in Figs. 44 to 46.

FIG. 44



Stratification of enamel; the cusp of a biscupid: *De*, dento-enamel junction; *Ed*, enamel defect showing in the heavy stratification band; *Ig*, interglobular spaces in the dentin. (About 40 ×)

At the time the rod at *A* (Fig. 45) was completely formed the rod at *B* was just beginning to form at its dentinal end. From this it would seem that any structural defect due to imperfect development would not follow the direction of the enamel rods from the surface to the dentin, but would follow the stratification lines; and if these structural defects influenced the penetration of caries, we should expect to have the direction of penetration modified. Fig. 44 shows a structural defect in the

enamel over a cusp following the stratification band, and it will be noticed also that there is a structural defect in the dentin at a corresponding position.

Fig. 45



Incisor tip showing stratification or incremental lines. Rods at *A* were fully formed at the time the rods at *B* were beginning to form. (About 50 ×)

HISTOLOGICAL REQUIREMENTS FOR STRENGTH IN ENAMEL WALLS

1. The enamel must be supported upon sound dentin.

2. The rods which form the cavosurface angle must run uninterruptedly to the dentin and be supported by short rods, with their inner ends resting on the dentin and their outer ends abutting upon the cavity wall, where they will be covered in by the filling material.

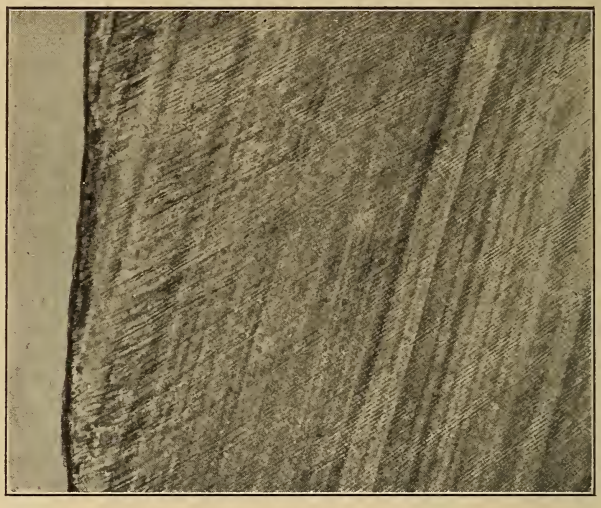
3. That the cavosurface angle be cut in such a way as not to expose the ends of the rods to fracture in condensing the filling material against them.

The first step, then, in the preparation of an enamel wall is to deter-

mine the direction of the enamel rods by cleavage with a chisel or hatchet.

In Figs. 47 and 48, No. 1 shows an enamel wall after cleaving the enamel with a hatchet. It will be noticed that the split has not followed the direction of the rods exactly, but has broken across them, slivering the rods as wood slivers in splitting. This would cause in the cut surface a whitish, opaque appearance. The plane of the enamel wall should be extended so as to form a small angle with the plane of the dentin wall, by shaving the surface with a very sharp hand instrument. No. 2 shows the same wall after it has been extended somewhat; but it will be seen that it has not been extended enough, for the rods forming the surface at *A* do not reach the dentin, but run out at *B* on the cavity wall, and that piece would chip out in packing against it or if force came upon

FIG. 46



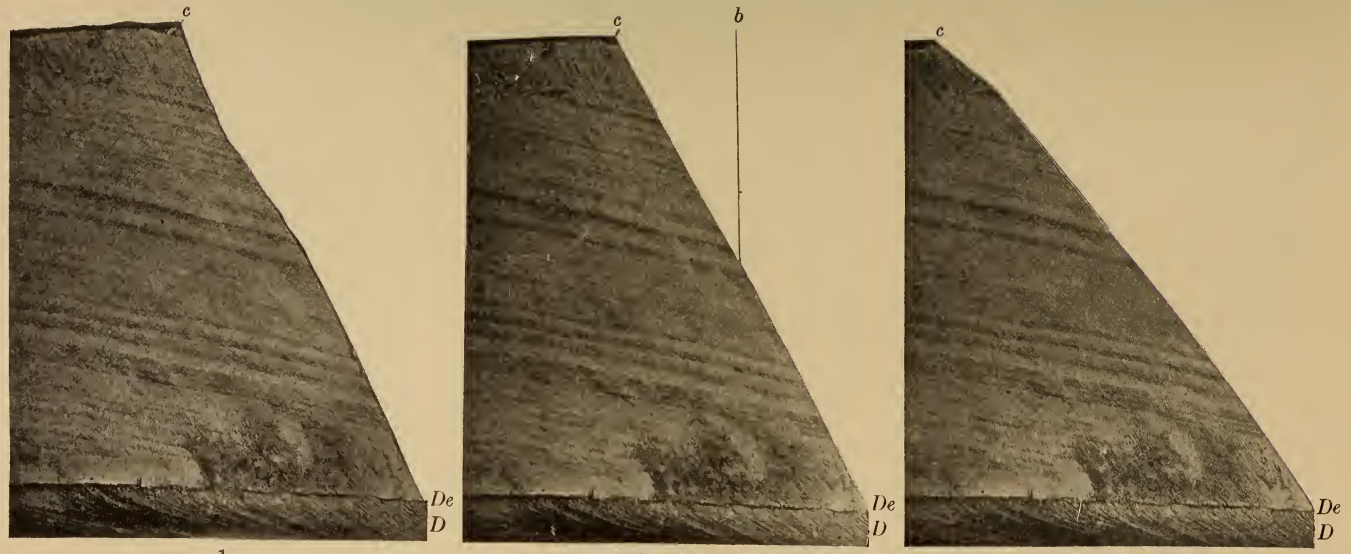
Enamel showing both striation and stratification. (About 80 ×)

the surface afterward. The angle should be extended so as to produce the plane shown in No. 3; then the cavosurface angle may or may not be bevelled as the position demands.

In some positions, as on the axial surfaces, it is not possible to extend the plane of the entire enamel wall as described; all that can be done is to shave the cut surface, leaving the wall in the direction of the enamel rods, and then the margin is strengthened by bevelling the cavosurface angle, so that the rods forming the margin are supported by at least a few rods which are covered by filling material.

In cutting out the fissures on the occlusal surfaces of molars and bicuspids, the rods are inclined centrally from the axial plane, as seen in Fig. 49. In opening a fissure the lines of cleavage will not be in the axial plane, but sloping inward toward the body of the cusp, in the

FIG. 47



Preparation of enamel wall in straight enamel: 1. Enamel wall as cleaved, showing breaking across rods. 2. Wall smoothed but not extended; some rods do not reach the dentin, but their inner ends are cut off at *b*. 3. Correctly trimmed and the cavo-surface angle slightly beveled. The inclination of the enamel rods is too great to make a good enamel wall in this position. *c*, cavo-surface angle; *De*, dento-enamel junction; *D*, dentin; *b*, point at which inner ends of rods are cut off. (About 80 ×.)

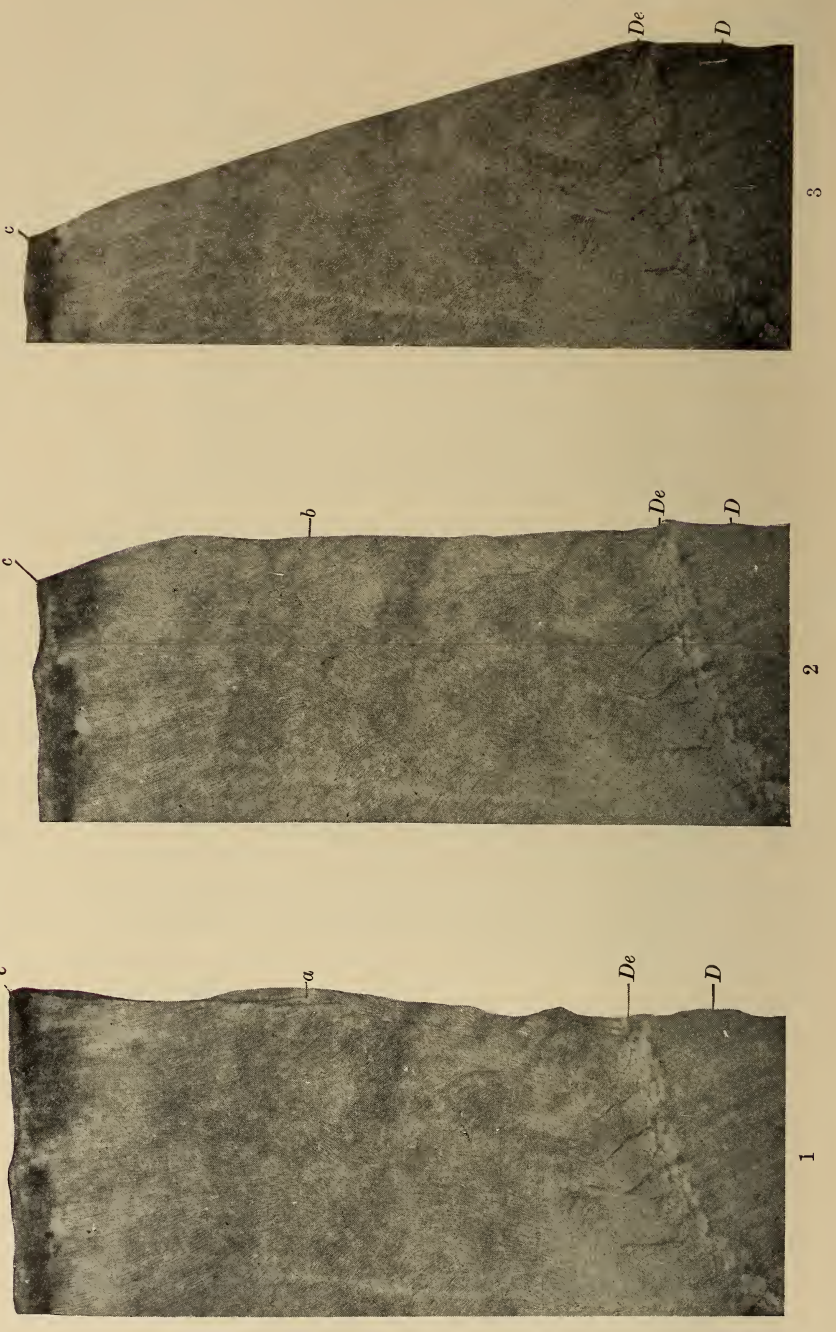


FIG. 48

Preparation of enamel wall in gnarled enamel: 1. Enamel wall as cleaved, showing breaking across rods and slivering at *a*. 2. Wall as smoothed but not extended to remove short rods whose inner ends are cut off at *b*. 3. Wall extended and trimmed to a position of strength. *D*, dentin; *De*, dento-enamel junction; *c*, cavo-surface angle; *b*, point where inner ends of rods are cut off; *a*, slivering of the tissue. (About 80 ×.)

direction indicated by the direction of the cracks in Fig. 49. The outer ends of the enamel rods must be shaved away, to bring the plane of the enamel wall parallel with the dentin wall or into the axial plane. When this has been done a strong margin has been formed, for the rods which form the point of the cavosurface angle are supported by the piece *A, B, C* (Fig. 50), made up of rods resting upon sound dentin

FIG. 49



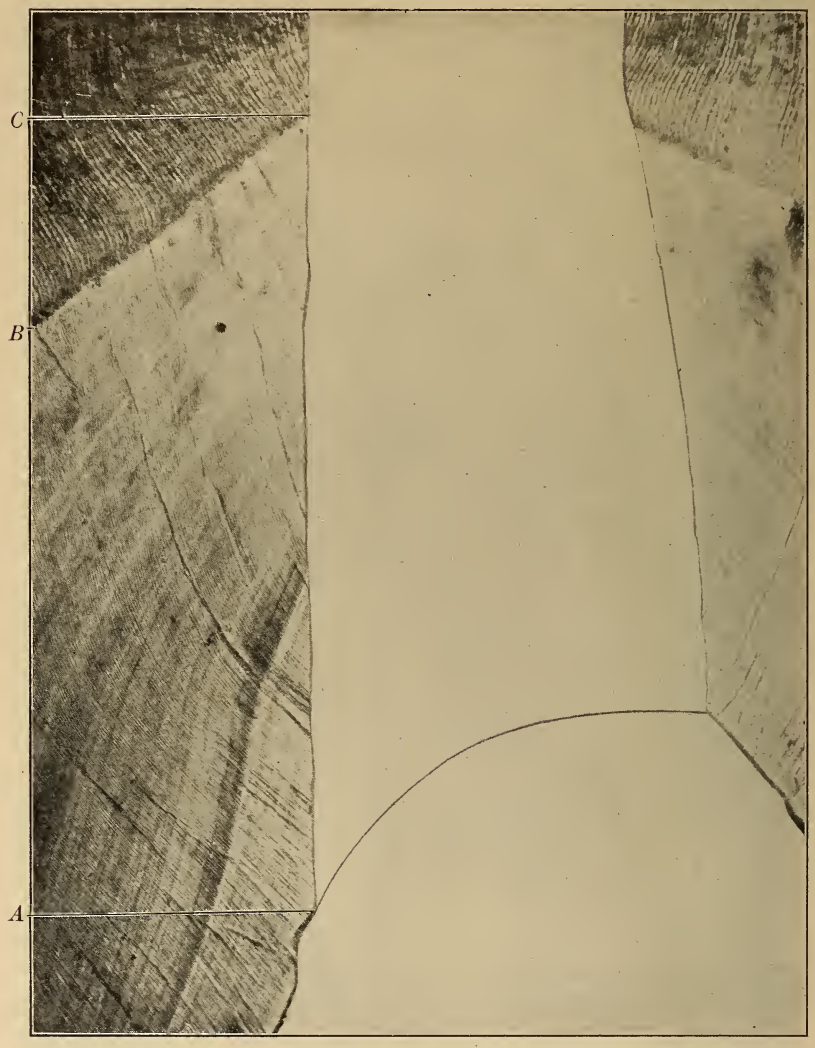
Occlusal fissure in an upper bicuspid, showing direction of rods. (About 80 ×)

and covered by the filling material. Often the angle will be too sharp, however, and the cavosurface angle should usually be bevelled to protect the margin from accident. This illustration may be taken as typical of occlusal cavities.

Fig. 51 shows a cavity prepared in the buccal surface of an upper molar. The occlusal margin is placed in the occlusal half of the middle third, and the gingival margin in the gingival half of the gingival third

of the surface. In the occlusal wall the rods are inclined occlusally about 8 centigrades (28 degrees) from the horizontal plane. After cleaving, the broken and slivered rods should be shaved away, but the angle cannot be increased without making the margin of filling material too

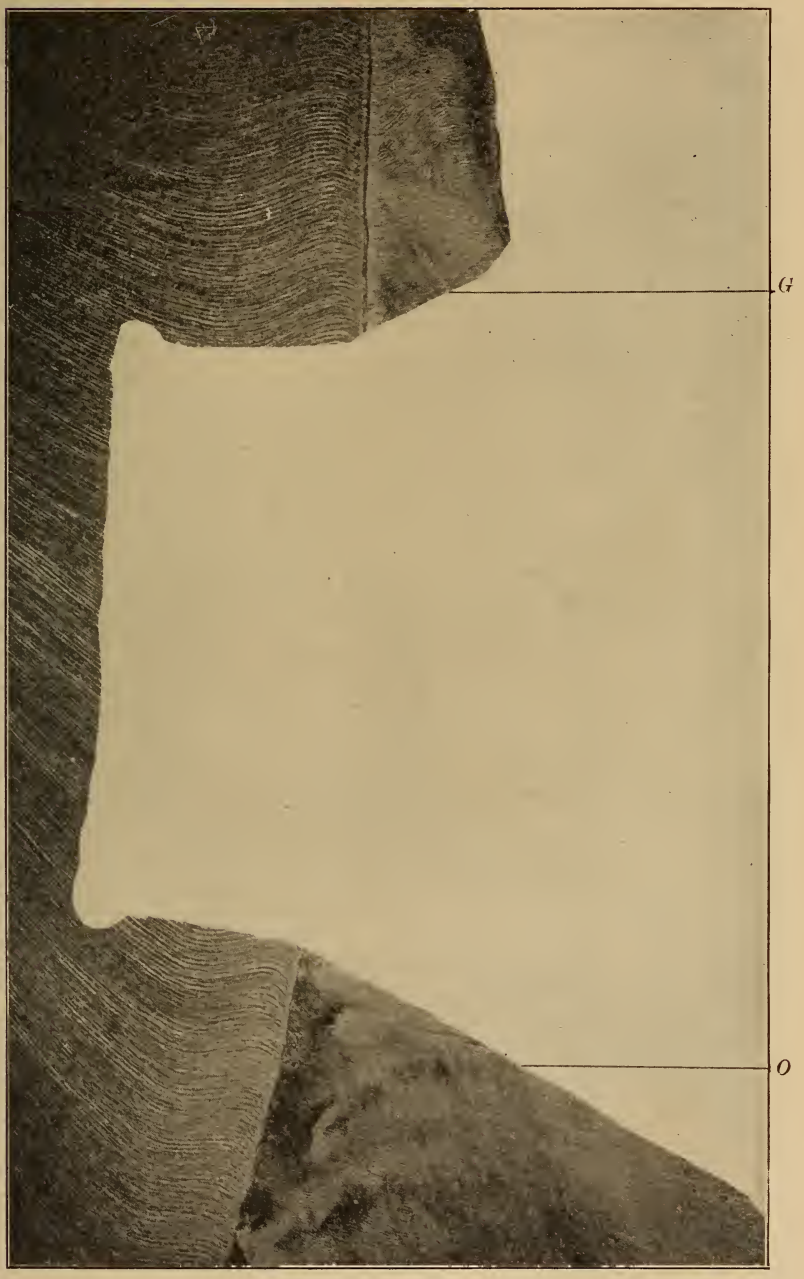
FIG. 50



Preparation of enamel walls in occlusal fissure cavities (the same as Fig. 49).

thin; the rods forming the margin should therefore be protected by bevelling the cavosurface angle. At the gingival wall the rods are inclined apically from the horizontal plane about 6 centigrades (20 degrees). The wall should be shaved in that plane, increasing the angle a little, and the cavosurface angle should be bevelled. Fig. 52 shows the occlusal

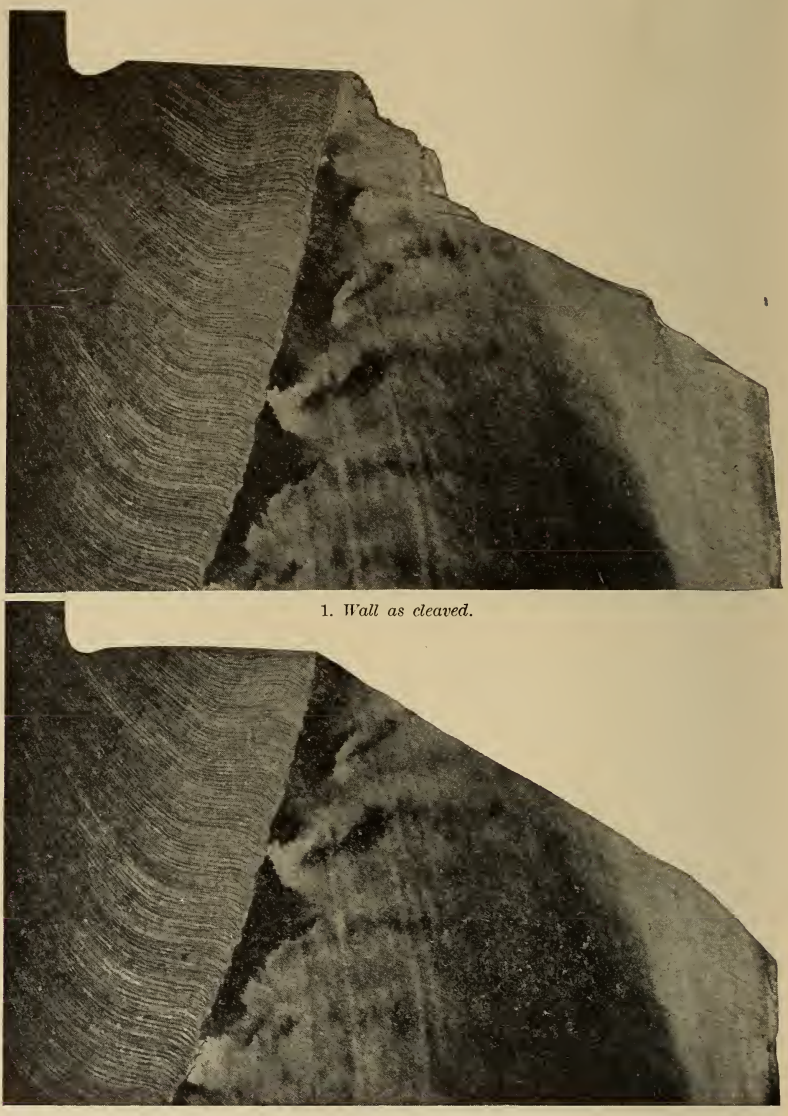
FIG. 51



Preparation of enamel walls in a buccal cavity in a molar: *G*, gingival wall; *O*, occlusal wall (About 70×.)

enamel wall alone, after cleaving and trimming into form. Such enamel walls may be taken as typical of axial surface cavities, the angle of the

FIG. 52



1. *Wall as cleaved.*

2. *Wall as trimmed.*

Preparation of occlusal wall of Fig. 51. (About 70 ×)

enamel with the dentin wall being determined by the direction of the enamel rods in the position where the margin is laid.

Grooves, fissures, and pits are always positions of weakness, and when a cavity approaches a groove or pit a good margin, histologically,

cannot be prepared without cutting beyond it. Fig. 53 shows an occlusal fissure in a bicuspid, which illustrates the conditions of structure characteristic of these positions. The rods are inclined toward the fissure, and between the bottom of the fissure and the dentin are very irregular. If a cavity wall were made to approach this fissure from the lingual side, so as to come to the dotted line, the wall would have to be inclined 6 to 8 centigrades (20 degrees to 28 degrees) from the axial plane toward the fissure, and then the cavosurface angle bevelled, when the conditions would be similar to those in the wall of an axial surface cavity, and not as strong as the location requires. Not only is this true,

FIG. 53



Structure of enamel about a fissure: *B*, buccal side; *L*, lingual side. (About 70 ×)

but it also leaves a vulnerable point next to the margin of the filling—a point of liability. Cutting just beyond the fissure, the wall may be left in the axial plane and have an ideally strong margin, and the point of liability is removed. To state the conditions in general terms, a strong margin is more easily obtained where enamel rods are inclined toward the cavity than where they are inclined away from the cavity.

The points of cusps and the crests of marginal ridges are positions of strength in the perfect tissue; but when a cavity margin approaches them they become points of weakness, because it is impossible to support properly the rods which form the margin. Over the marginal

ridges are many short rods which do not reach the dentin, and these are usually much twisted about each other, so as to form the strongest possible keystone in the perfect structure. In preparing a margin in such a position it is impossible to have the rods which form the margin reach the dentin with their inner ends, and these short rods are sure either to break in completing the operation or to break out later. The arrangement of enamel rods in such positions is to be borne

FIG. 54



Bucco-lingual section of upper bicuspid; enamel is broken from grinding: *A* to *B*, area of weakness for enamel margins. (About 20 ×)

in mind, especially when extending approximal cavities in incisors toward the lingual side and in large pit cavities in incisors. A similar condition is found over the points of the cusps. Fig. 54 shows a bucco-lingual section of an upper bicuspid. It will be noticed that the rods forming the point of the cusp are not in the axial plane, and do not reach the tip of the dentin cusp, but reach the dentin a little way down on the outer slope. The enamel covering the tip of the dentin

contains many short rods, and they are very much twisted about each other, so that the area from *A* and *B* to the point of the cusp is an area of weakness for cavity margins. If the margin reaches this area, the

FIG. 55

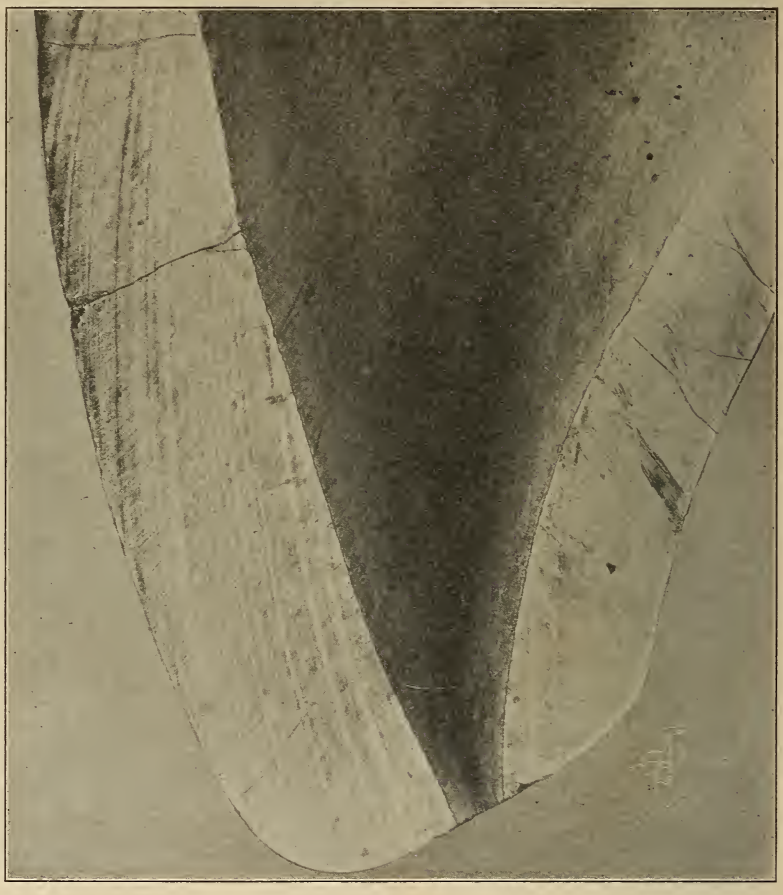


Enamel over tip of dentin cusp: *D*, dentin cusp. (About 80 ×)

cusp must be cut away and the enamel wall carried out in the horizontal plane. Fig. 55 shows this area more highly magnified, and illustrates the structure. It will be noticed that, in grinding, some of the short twisted rods have broken out of the section.

Fig. 56 shows the tip of an incisor in labiolingual section, and is of interest in relation to the formation of margins in step cavities in incisors. The tip of this tooth has been worn off in use. The illustration shows that the great inclination of the rods toward the axial plane in the occlusal third of the incisors is such as to bring the wear almost at right angles to the direction of the rods.

Fig. 56



Tip of an incisor. (About 50 ×)

DENTIN

The structure of dentin is of comparatively little interest in the present consideration, as its histological forms do not directly influence the cutting of the tissue in the excavation of cavities. Its histological forms have, however, much to do with the penetration of caries and with other considerations which are of importance to the intelligent practice of operative dentistry.

Dentin belongs to the connective-tissue group, and is made up of a solid organic matrix impregnated with about 72 per cent. of inorganic salts[1] and pierced by minute canals or tubules, which radiate from a central cavity which contains the remains of the formative organ, or pulp. The minute canals, or *dentinal tubules*, are occupied in life by protoplasmic processes from the odontoblastic cells which form the

Fig. 57



Dentin at dento-enamel junction, showing tubules cut longitudinally: *Dt*, dentinal tubules; *D*, dentin matrix. (About 760 ×)

outer layer of the pulp. Dentin contains two kinds of organic matter, the contents of the tubules and the organic basis of the matrix. The dentin matrix, after the removal of the calcium salts by acids, yields gelatin on boiling and resembles the matrix of bone, reacting in a similar, though not identical, way with staining agents. The portion of the

[1] Von Bibra gives the following analysis of dentin:

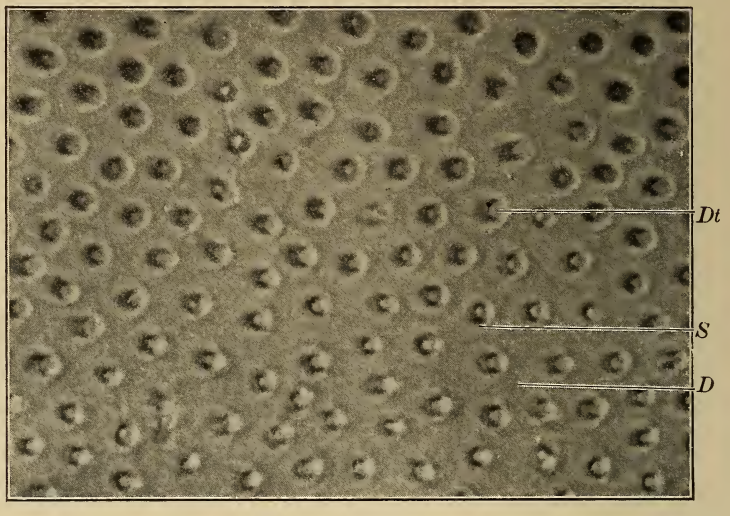
Organic matter	27.61
Fat	0.40
Calcium phosphate and fluorid	66.72
Calcium carbonate	3.36
Magnesium phosphate	1.08
Other salts	0.83

matrix immediately surrounding the tubules shows different chemical characteristics from the rest of the matrix, resembling elastin, and resisting the action of strong acids and alkalies after the rest of the tissue has been destroyed. This portion of the matrix surrounding the tubules and lying next to the fibrils is known as the *sheaths of Neumann.*

The dentinal tubules are from 1.1 to 2.5 microns in diameter, and are separated from each other by a thickness of about 10 microns of dentin matrix. This is fairly uniform throughout the dentin. The character of the tubules is different in the crown and root portions.

In the crown the tubules branch but little through most of their course; but in the outer part, close to the enamel, they branch and anastomose with each other quite freely. Fig. 57 shows a field of dentin

FIG. 58



Dentin showing tubules in cross-section: *Dt*, dentinal tubules; *D*, dentin matrix; *S*, shadow of sheaths of Neumann. (About 1150 ×)

just beneath the enamel, as seen with a high power, and shows the diameter of the tubules, their branching, and the amount of matrix between one tubule and the next. The relation of one tubule to each other is shown also in sections cut at right angles to their direction (Fig. 58). In the crown portion the tubules pass from the pulp chamber to the dento-enamel junction in sweeping curves, so as to enter the pulp chamber at right angles to the surface, and end next to the enamel at right angles to that surface. This produces S- or F-shaped () curves, which are known as the primary curves of the tubules. Throughout their course the tubules are not straight, but show a great many wavy curves, known as the secondary curves. These appear as waves

when seen in longitudinal sections, but are really the effect of an open spiral direction, as is seen by changing the focus of the microscope in studying sections cut at right angles to the direction of the tubules. The branches throughout their length are few and small, and are given off at an acute angle to the direction of the tubule; but just before the enamel is reached the tubules fork and branch, producing an appearance similar to the delta of a river. These branches are given off from the tubules for some little distance back from the enamel, and they anastomose with other tubules very freely. The branching of the tubules in their outer portion causes the spreading of caries just beneath the

Fig. 59



Crown of a molar, mesio-distal section, showing penetration of caries: *A*, caries penetrating dentin; *B*, line of abrasion; *P*, pulp chamber. (About 20 ×)

enamel, the microörganisms growing through the branches from tube to tube, and so spreading sideways beneath the enamel plates, and then penetrating the dentin in the direction of the tubules. Fig. 59 shows the penetration of caries in the dentin. It will be noticed that in decay starting at the contact point there has been more spreading under the enamel than in that starting at the gingival line, but in both positions the penetration has followed the direction of the tubules.

In the root portion the tubules pass out from the pulp canals at right angles to the long axis of the tooth and pass directly out to the cementum, showing only the secondary curves. Throughout their course they give off a great many fine branches passing through the matrix in all

FIG. 60



Dentin from the root, showing tubules cut longitudinally. (About 700×)

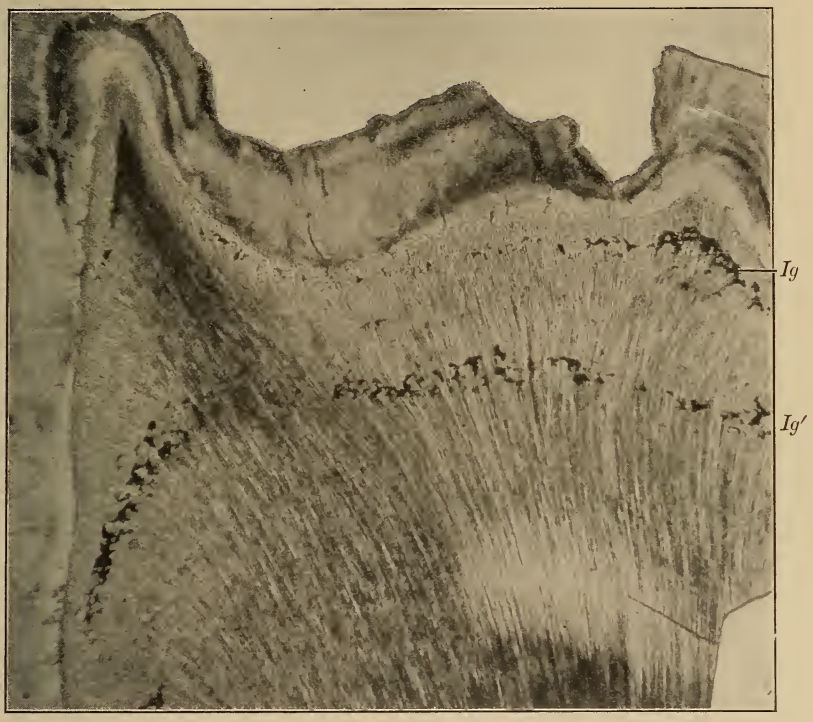
FIG. 61



Dento-enamel junction. (About 70×)

directions from tubule to tubule. These branches are so numerous that in sections which have been mounted in such a way as to leave air in them, or if the tubules have been filled with coloring matter, they give the impression of looking through a hazel bush; or they may be likened to the fine rootlets of a plant. These fine branches are shown in Fig. 60, and the character of the dentin in the root portion is to be compared with that in the crown portion as shown in Fig. 57. The outermost layer of the dentin next to the cementum contains many small irregular

FIG. 62



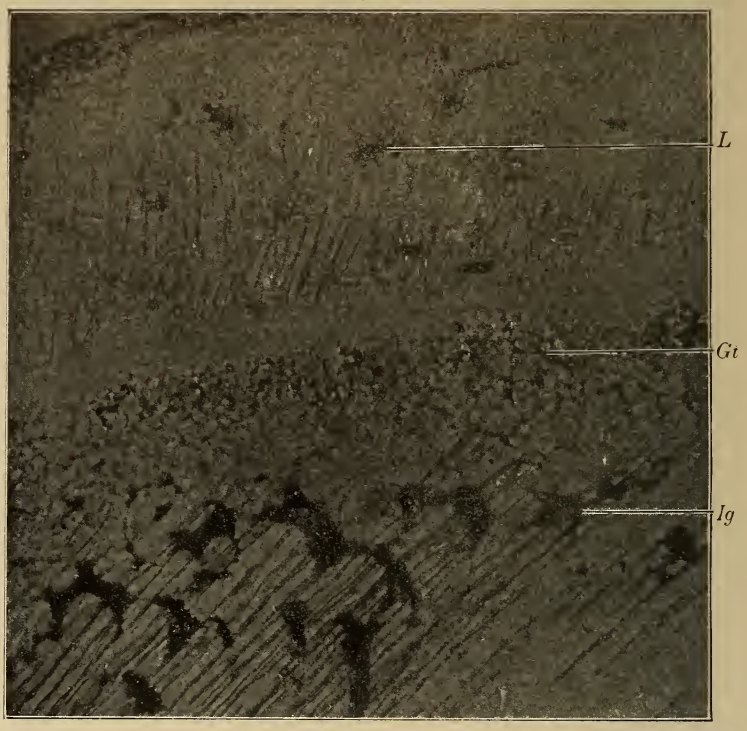
Interglobular spaces in dentin: *Ig*, first line of interglobular spaces; *Ig′*, second line of interglobular spaces. (About 30 ×)

spaces, which connect with the dentinal tubules and give to the tissue when seen with low powers a granular appearance. This layer was first described by John Tomes as the granular layer, and has since been usually called the *granular layer of Tomes*. The spaces of the granular layer are probably filled by the enlarged ends of the dentinal fibrils. The same appearance is sometimes seen beneath the enamel, but is never as well marked as next to the cementum.

The dentin at the dento-enamel junction seldom presents a smooth surface, but the inner surface of the enamel plate shows rounded projections, between which the dentin extends. In sections this gives to

the dento-enamel junction a scalloped appearance, as shown in Fig. 61; and often the deceptive appearance of the dentinal tubules penetrating for a short distance between the enamel rods.

Fig. 63



Granular layer of Tomes: *L*, lacunæ of cementum *Gt*, granular layer of Tomes; *Ig*, interglobular spaces. (About 200 ×)

In many specimens made by grinding dried teeth large irregular spaces are very conspicuous in the dentin. They usually occur in lines or zones at about uniform depth from the surface. These have been called the interglobular spaces. They are really not spaces at all, but are areas of imperfect development in which the dentin matrix has not been calcified. The dentinal tubules pass through them without interruption. In a dried specimen the organic matrix shrinks, and the resulting space becomes filled with the debris of grinding, so as to give the appearance of black spaces. Fig. 62 shows two quite distinct layers of interglobular spaces, the second much more marked than the first; and in the enamel at a position corresponding to the first is seen an imperfection of structure marked by the very dark stratification band. This is shown best in the region of the cusp (Fig. 44) from the same section. Interglobular spaces in the root portion of the dentin are shown in Fig. 63, close to the granular layer of Tomes.

The formation of dentin is not complete at the time of eruption of the tooth, but continues for an indefinite period, thickening the layer of dentin at the expense of the pulp. When the typical amount of dentin has been formed the growth ceases, and does not begin again unless excited by some irritation to the pulp or the pulp of some other tooth of the same side, which leads to the formation of secondary dentin. Secondary dentin is never as perfect in structure as primary dentin; the tubules are smaller, fewer, and much more irregular. Often in ground sections several periods of formation can be determined by differences of structure, each deposit becoming successively more and more imperfect in structure. This is shown in Fig. 64.

Fig. 64



Secondary dentin: *A*, margin of primary dentin, showing a few of the tubules continuing into the secondary dentin; *P*, pulp chamber. (About 80 ×)

PULP

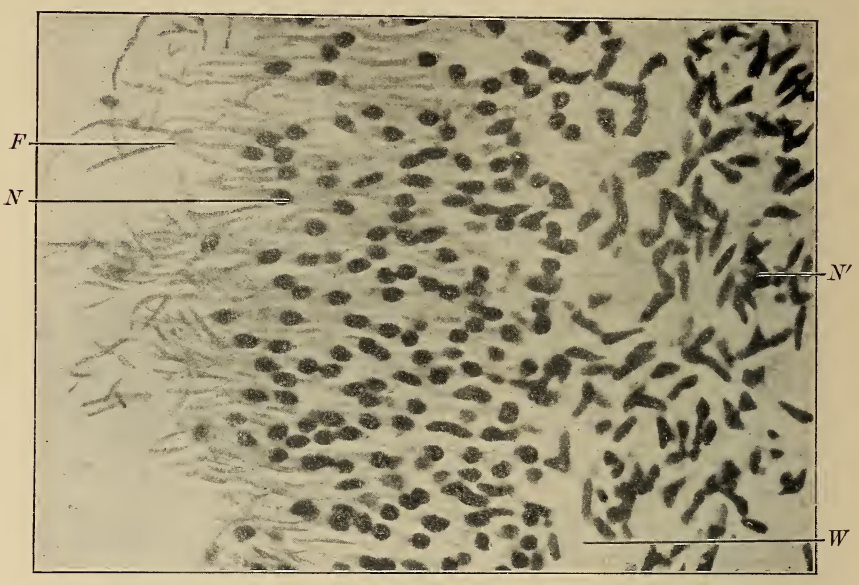
The dental pulp is the soft tissue occupying the central cavity of the dentin. It is made up of embryonal connective tissue and contains a large number of bloodvessels and nerves. Like all connective tissues, the intercellular substance is large in amount and the cells are widely scattered in this soft, jelly-like tissue, which contains but few fibers. We recognize four kinds of cells in the pulp—the odontoblasts, forming

the outer surface of the pulp next to the dentin; and round, spindle-shaped, and stellate connective-tissue cells.

Arrangement of Cells.—The *odontoblasts* are tall columnar cells, sometimes club-shaped, and in older tissues, which have ceased to be functional, sometimes becoming almost spherical. They form a continuous layer over the entire surface of the pulp, being everywhere in contact with the dentin. The layer has been called the *membrana eboris*, or the "membrane of the ivory."

The nuclei of the odontoblasts are large and oval, containing a large amount of chromatin, and are very different from the nuclei of ordinary connective-tissue cells.

FIG. 65



Odontoblasts. The section cuts obliquely through the odontoblasts: *F*, fibrils; *N*, nuclei of odontoblasts; *N′*, nuclei of connective-tissue cells; *W*, layer of Weil, not well shown. (About 80 ×)

Three kinds of processes have been described in connection with the odontoblasts:

1. The dentinal fibril processes, or *fibers of Tomes*. These are long, slender protoplasmic processes projecting from the dentin end of the cell into a dentinal tubule, and running through the tubule to the outer surface of the dentin. Usually there is but one fibril extending from each odontoblast, but sometimes two can be seen, extending into two tubules. These fibrils can be demonstrated in decalcified sections or by removing the pulp from a recently extracted tooth by cracking the tooth and carefully lifting the pulp out of the pulp chamber, and then either teasing or sectioning. Fig. 65 shows the fibrils projecting from the surface; but in this section the cut was not in the direction of the long axis of the odontoblasts, but obliquely through them. Fig. 66

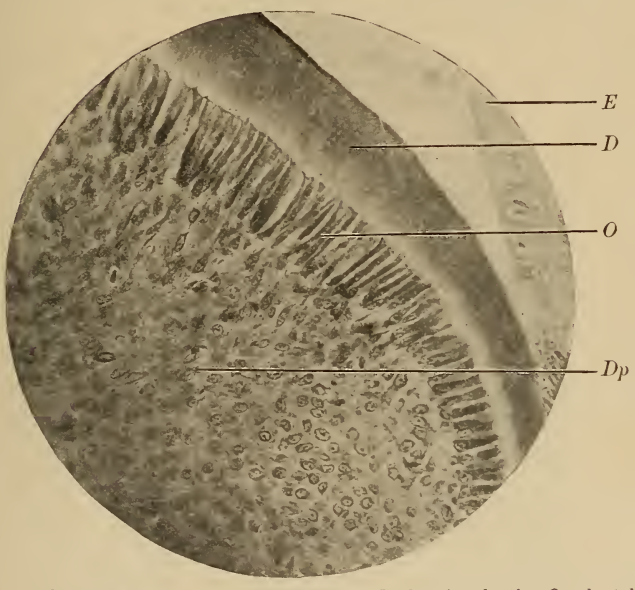
(from a photograph by Rose) shows the form of the odontoblasts in a young tooth in which formation of dentin is actively progressing, with the fibrils in the dentinal tubules.

2. Lateral processes projecting from the sides of the cells and uniting one with another in the formation of the layer.

3. Pulpal processes, projecting from the pulpal ends of the odontoblasts into the layer of Weil.

The odontoblasts, as the name indicates, are the dentin-forming cells. They superintend the formation and calcification of the dentin matrix, the fibril being left behind surrounded by the formed tissue. Whether the fibrils have any share in the formation and calcification of the dentin matrix has been a matter of controversy.

FIG. 66



Odontoblasts and forming dentin: *E*, forming enamel; *D*, forming dentin; *O*, odontoblasts; *Dp*, body of dental papilla. (From photomicrograph by Röse.)

The relation of the fibrils to the transmission of sensation is also a matter of dispute; but at present the weight of evidence is that they in some way transmit impressions to the sensory nerves of the pulp.

Just beneath the layer of odontoblasts is a zone which contains very few connective-tissue cells. In thin sections, especially in the body of the pulp, this appears as a clear layer about half as thick as the layer of odontoblasts. It is known as the *layer of Weil.* Just beneath the layer of Weil the connective-tissue cells are especially numerous and form a more or less distinct layer of closely placed cells. In the rest of the body of the pulp the cells are about uniformly distributed throughout

the intercellular substance. These connective-tissue cells are of the characteristic forms, rather small, containing a small but deep-staining

FIG. 67

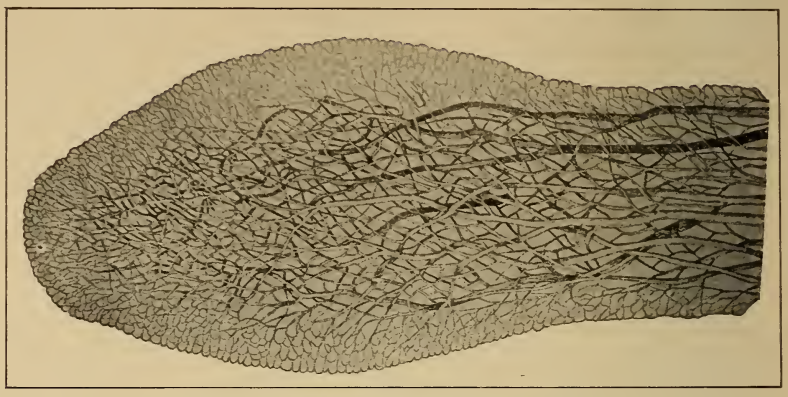


Diagram of the bloodvessels of the pulp. (Stowell.)

FIG. 68



A pulp bloodvessel, showing the thin wall: *C*, blood corpuscles in the vessel; *Bl*, bloodvessel wall showing nuclei of endothelial cells; *N*, nuclei of connective-tissue cells in the body of the pulp; *I*, intercellular substance, showing a few fibers. (About 200×)

nucleus, the protoplasm stretching out into slender projections in two directions to form the spindle cells, or in more than two directions to

form the stellate cells. The stellate forms are more common in the body of the pulp, the spindle form in the canal portions. The round cells are comparatively few in number, and are probably young cells which have not yet acquired the adult form.

The Bloodvessels of the Pulp.—The blood supply of the pulp is extremely rich, several arterial vessels entering in the region of the apex of the root, often through several foramina. These large vessels extend occlusally through the central portion of the tissue, giving off many branches which break up into a very close and fine capillary plexus (Fig. 67). From the capillaries the blood is collected into the veins, which pass apically through the central portion of the tissue. A very striking peculiarity of the bloodvessels of the pulp is the thinness of their walls. Even the large arteries show scarcely any condensation of fibrous tissue around them to form the usual adventitious layer, and usually contain but a single involuntary muscle fiber representing the media, while the walls of even the large veins are made up of only the single layer of endothelial cells forming the intima, and are in structure like large capillaries (Fig. 68). This peculiarity of the bloodvessel walls is of great importance, as it renders the tissue especially liable to such pathological conditions as hyperemia and inflammation.

The Nerves of the Pulp.—Several comparatively large bundles of medullated nerve fibers, containing from six or eight to fifteen or twenty fibers, enter the pulp in company with the bloodvessels and pass occlusally through the central portion of the tissue. These bundles branch and anastomose with each other very freely. Most of the fibers lose their medullary sheath before reaching the layer of Weil, in which position they form a plexus of non-medullated fibers; from these fibers free endings are given off, which penetrate between the odontoblasts. In some cases these have been followed over on to the dentinal ends of the odontoblasts, but in no instance have they been followed into the dentinal tubules.

The Functions of the Pulp.—The pulp performs two functions, a vital and a sensory.

The *vital function* is the formation of dentin, and is performed by the layer of odontoblasts. This is the principal function of the pulp, and it is first manifested in the development of the tooth before the dentinal papilla is converted into the dental pulp by being enclosed in the formed dentin. After the tooth is fully formed the vital function is not manifested unless the pulp is stimulated by some excitation affecting trophic centres and which causes the formation of secondary dentin. There are some exceptions where the formation is entirely local.

The Sensory Function.—In regard to sensation, the pulp resembles an internal organ. It has no sense of touch or localization, and responds to stimuli only by sensations of pain. The pain is usually localized correctly with reference to the median line, but, aside from that, is

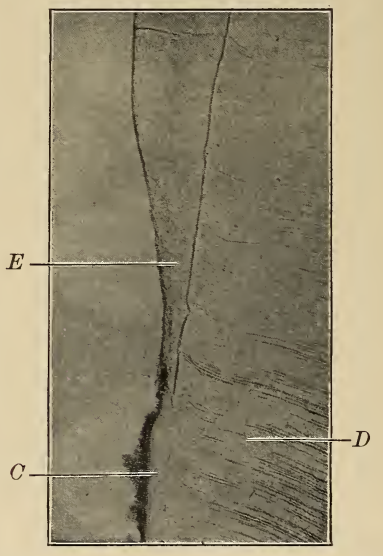
localized only as it is referred to some known lesion. If several pulps on the same side of the mouth and in teeth of both the upper and lower arches were exposed so that they could be irritated without impressions reaching the peridental membrane, and the patient were blindfolded, it would be impossible for him to tell which of the pulps was touched. The pain originating from a tooth pulp may be referred to the wrong tooth or to almost any point on the same side supplied by the fifth cranial nerve.

The pulp is especially sensitive to changes of temperature, but is incapable of differentiating between heat and cold; this fact is often made use of in differential diagnoses. The pulp is also very sensitive to traumatic and chemical irritations, even when these are conveyed to it through the agency of the dentinal fibrils. Dr. Huber has suggested[1] that this transmission may be accomplished by the traumatic or chemical action upon the fibrils setting up metabolic changes in the odontoblastic cells, which act as stimuli to the sensory nerves ending between the cells of that layer.

CEMENTUM

The cementum covers the surface of the dentin apically from the border of the enamel, lapping slightly over the enamel at the gingival margin (Fig. 69). It forms a layer, thickest in the apical region and

FIG. 69



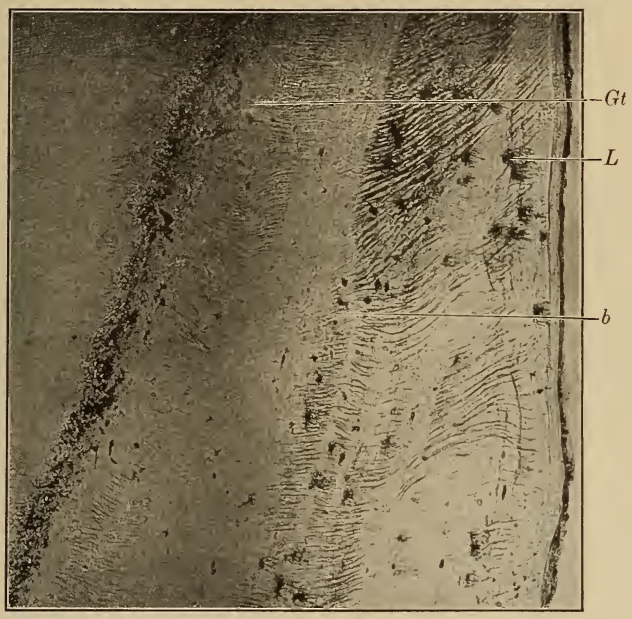
Gingival border of enamel, showing the cementum overlapping it: *E*, enamel; *C*, cementum; *D*, dentin. (About 40 ×)

[1] Dental Cosmos, October, 1898.

between the roots of bicuspids and molars, and becoming thinner as the gingival line is approached. The cementum resembles subperiosteal bone in structure, but differs from it in the character and arrangement of the lacunæ and in the absence of Haversian systems; the layers, or lamellæ, of the cementum also are less uniform in character than those of bone.

The function of the cementum is to furnish attachment for the fibers of the peridental membrane which holds the tooth in its position. The surrounding tissues are never in physiological connection with the outer surface of the dentin, except to form cementum over it or to

FIG. 70

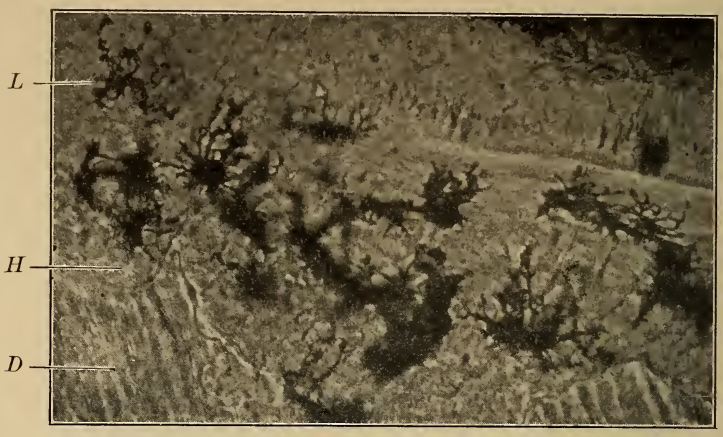


Cementum near the apex of the root: *Gt*, granular layer of Tomes; *L*, lacunæ, *b*, point at which fibers were cut off and reattached. (About 54 ×)

remove its substance by absorption; and when absorption of the dentin has occurred on the surface of a root it is never repaired except by the formation of cementum to fill up the cavity and reattach the membrane.

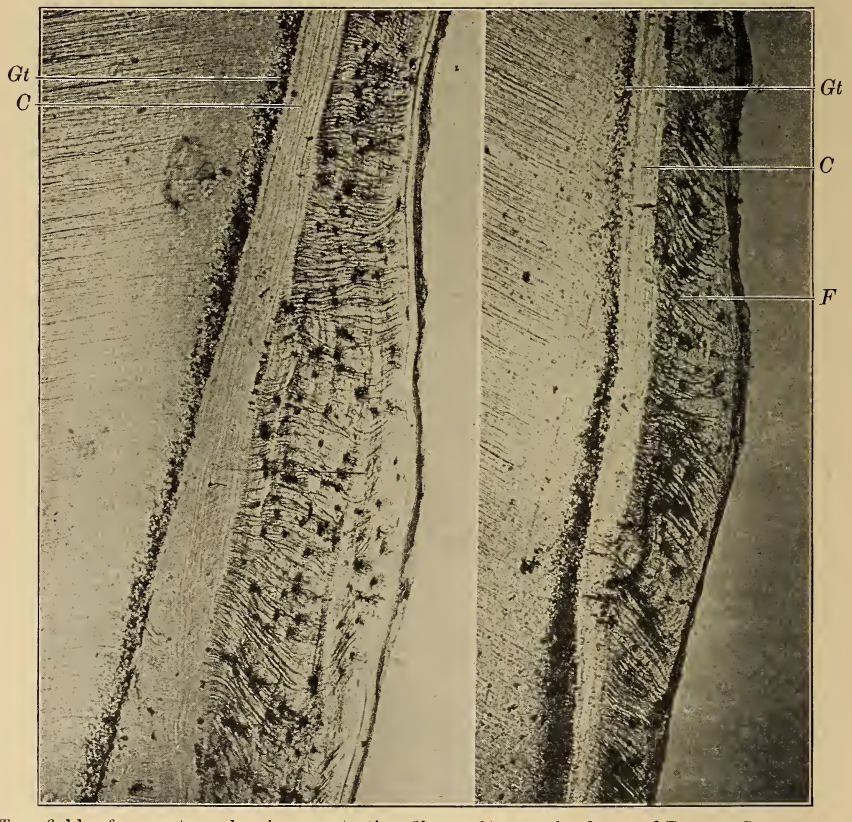
The cementum is intermittently formed during the functioning of the tooth, being added layer after layer over the entire surface of the root, the difference in thickness of the tissue in the gingival and apical portions being chiefly, though not entirely, due to the difference in thickness of each layer in the two positions (Figs. 69, 70). The cementum on the roots of newly erupted teeth is thin, and on the roots of teeth of old persons is thick. This continued formation of cementum

FIG. 71



Thick lamellæ of cementum with many lacunæ, filling an absorption in dentin: *L*, lacunæ; *H*, Howship's lacunæ filled; *D*, dentin. (About 250×.)

FIG. 72



Two fields of cementum showing penetrating fibers: *Gt*, granular layer of Tomes; *C*, cementum not showing fibers; *F*, penetrating fibers. (About 54×.)

is due to the necessity for change and reattachment of the fibers of the membrane.

In the gingival portions, where the cementum is thin, the tissue is clear and apparently structureless, and usually contains no lacunæ; while in the apical half and between the roots the lacunæ are numerous. In general, wherever the lamellæ are thin, the lacunæ are absent; but where the lamellæ are thick they are found. The canaliculi which radiate from the lacunæ are not as regular as in the case of the lacunæ of bone. Sometimes they are numerous, sometimes few; they may extend from a lacuna in all directions, or they may be confined to one side, usually the side toward the surface of the cementum (Fig. 71).

The cementum is penetrated through all its layers by fibers of the peridental membrane which have been embedded in the matrix of the tissue and calcified along with it. The first layer—that is, the one next to the dentin—is usually structureless and shows no fibers in it, at least in its inner half. In ground sections the embedded fibers often appear in a number of layers, while they are not apparent in the rest of the thickness. This is because just before and just after the formation of the layers in which they appear the fibers were cut off and reattached, changing their direction, so that in the other layers the fibers are cut transversely or obliquely. This is illustrated in Fig. 72. These embedded fibers are very numerous in some places. If properly stained, the tissue seems almost a solid mass of fibers. In ground sections these have sometimes been mistaken for minute canals from the fact that they are not always as fully calcified as the cementum matrix, and shrinkage causes the appearance of little open canals.

Hypertrophies of the cementum (formerly often called exostoses, or excementoses) are very common. The increased thickness may be of one lamella or of several lamellæ in the region of the hypertrophy, or all of the layers from first to last may take part in it. Small local thickenings of a single lamella are seen in connection with the peridental membrane wherever a specially strong bundle of fibers is to be attached to the root to support the tooth against some special strain.

PERIDENTAL MEMBRANE

The peridental membrane may be defined as the tissue which fills the space between the root of the tooth and the bony wall of its alveolus, surrounds the root occlusally from the border of the alveolus, and supports the gingiva. It has been referred to under many names, as pericementum, dental periosteum, alveolodental periosteum, etc. While this tissue performs the functions of a periosteum for the bone of the alveolus, it differs in structure from the periosteum in any position, so that any name including the word periosteum or implying a double membrane should be avoided.

The peridental membrane belongs to the class of fibrous membranes, and is made up of the following structural elements:

FIG. 73

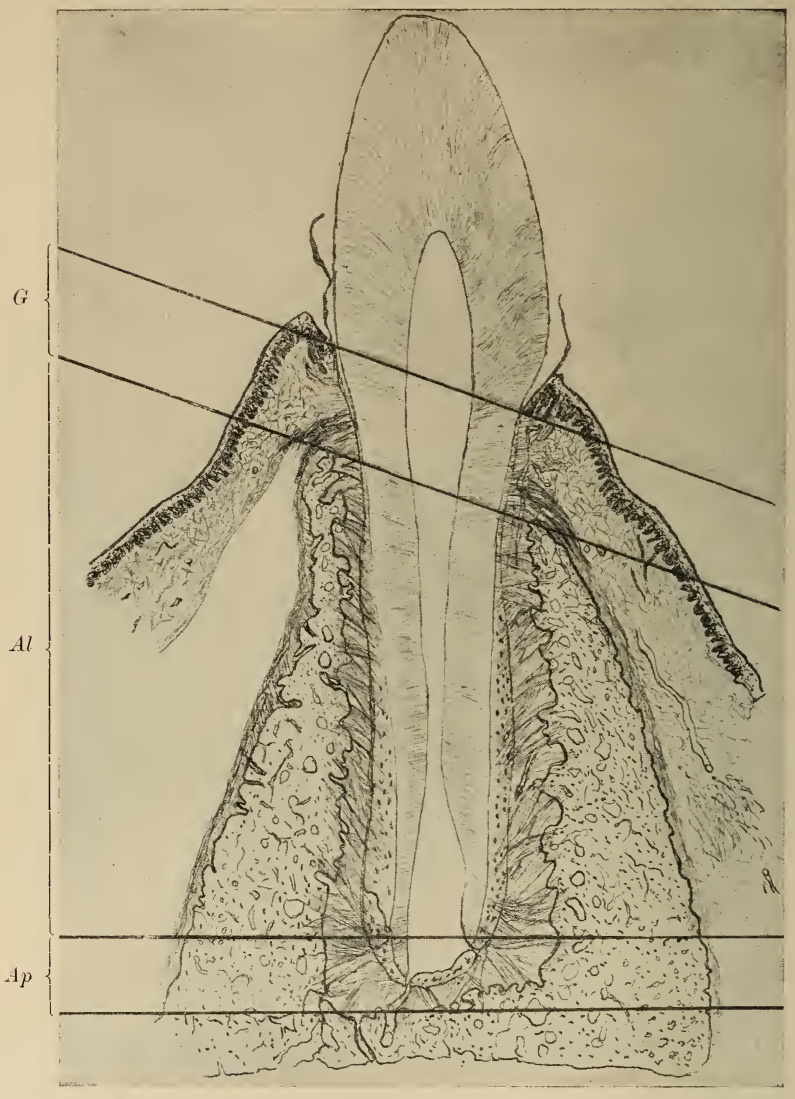


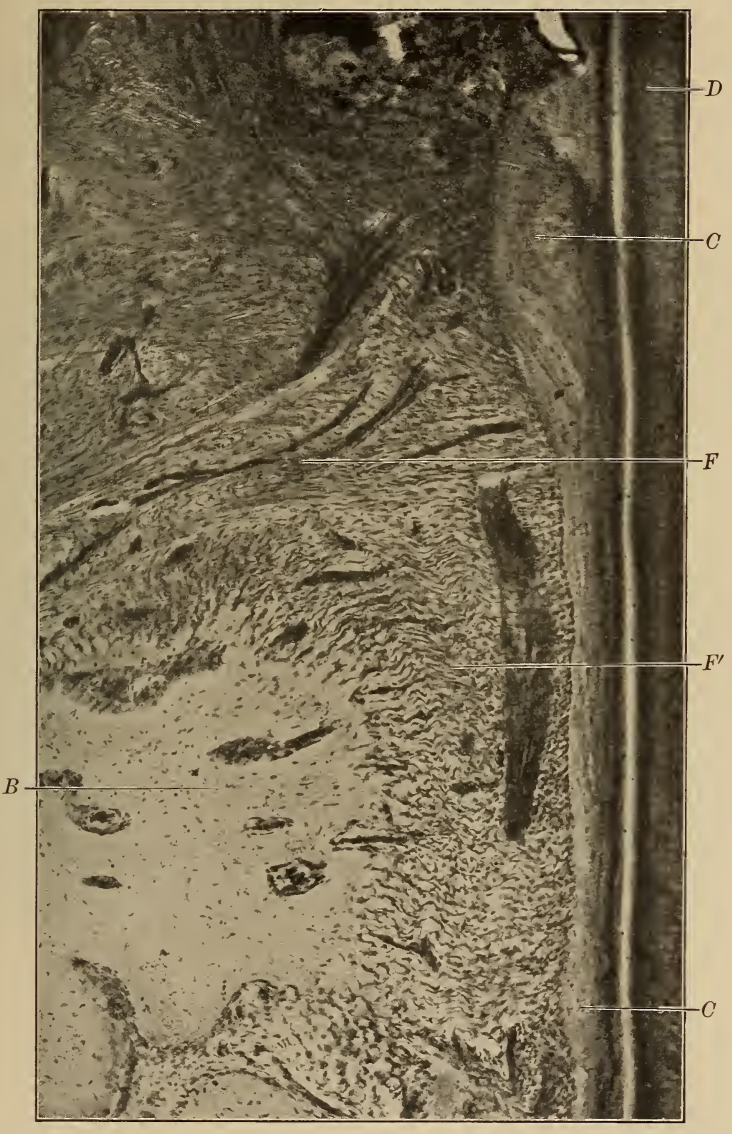
Diagram of the fibers of the peridental membrane: *G*, gingival portion; *Al*, alveolar portion; *Ap*, apical portion. (From a photograph of a section from incisor of sheep.)

1. Fibers. 2. Fibroblasts. 3. Cementoblasts. 4. Osteoblasts. 5. Osteoclasts. 6. Epithelial structures which have been called the glands of the peridental membrane. 7. Bloodvessels. 8. Nerves.

The peridental membrane performs three functions—a *physical*

function, maintaining the tooth in relation to the adjacent hard and soft tissues; a *vital* function, the formation of bone on the alveolar

Fig. 74

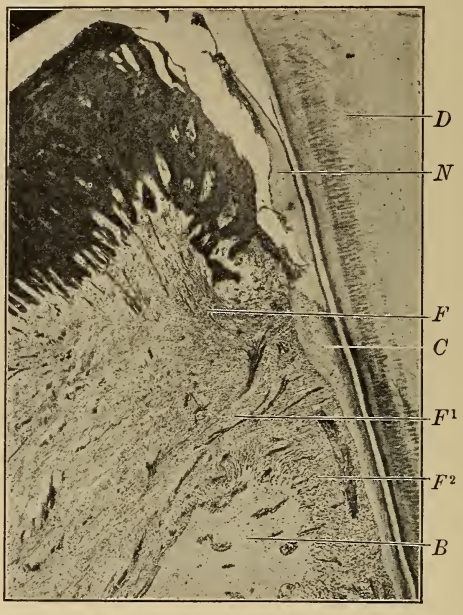


Longitudinal section of peridental membrane from young sheep, showing fibers penetrating cementum: *D*, dentin; *C*, cementum, showing embedded fibers; *F*, fibers running to outer layer of periosteum covering the alveolar process; *F′*, fibers running to the bone at the border of the process; *B*, bone. (About 80 ×)

wall and of cementum on the surface of the root; and a *sensory* function, the sense of touch for the tooth being exclusively in this membrane.

The fibrous tissue of the membrane is of the white variety, and may be divided into two classes, the principal fibers and the indifferent or interfibrous tissue. The principal fibers may be defined as those which spring from the cementum and are attached at their other end to the bone of the alveolar wall, to the outer layer of the periosteum covering the surface of the alveolar process, to the cementum of the approximating tooth, or become blended with the fibrous mat of the gum supporting the epithelium. They were so called by Dr. Black, not only because they form the principal bulk of the tissue, but they also perform the principal function of the membrane, the support of the tooth and sur-

FIG. 75



Longitudinal section of the peridental membrane in the gingival portion: *D*, dentin; *N*, Nasmyth's membrane; *C*, cementum; *F*, fibers supporting the gingivus; F^1, fibers attached to the outer layer of the periosteum over the alveolar process; F^2, fibers attached to the bone at the rim of the alveolus; *B*, bone. (About 30 ×)

rounding tissues. The interfibrous tissue, also of the white variety, but made up of smaller and more delicate fibers, is found filling spaces between the principal fibers and surrounding and accompanying the bloodvessels and nerves.

For convenience of description and study, the peridental membrane is divided into three portions: the *gingival,* that portion which surrounds the root occlusally from the border of the alveolar process; the *alveolar,* the portion from the border of the process to the apex of the root; and the *apical* portion, surrounding the apex of the root and filling the apical region (Fig. 73).

The principal fibers spring from the cementum, the cementoblasts building up the matrix around them and then calcifying both matrix and fibers, in this way implanting their ends into the surface of the root. In Fig. 74 the fibers are seen passing through the last-formed layer of cementum. In most positions the fibers as they spring from the cementum appear as well-marked bundles of fine fibers. A short distance from the surface of the root they break up into smaller bundles, which interlace and are reunited into larger bundles, to be attached at their other extremity to the bone, cementum, or fibrous tissue.

FIG. 76



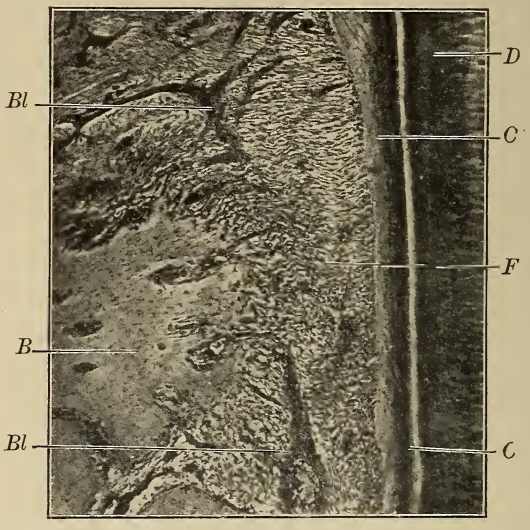
Transverse section of the peridental membrane in the gingival portion (from sheep): *E*, epithelium: *F*, fibrous tissue of gum; *B*, point where peridental membrane fibers are lost in fibrous mat of the gum; *P*, pulp; *F′*, fibers extending from tooth to tooth. (About 30 ×)

To arrive at an understanding of the arrangement of the fibers of the peridental membrane, they must be studied in both longitudinal and transverse sections. In longitudinal sections of the membrane, in the gingival portion (Fig. 75), the fibers springing from the cementum at the gingival line pass out for a short distance at right angles to the long axis of the tooth and then bend sharply to the occlusal,[1] passing

[1] In describing the direction and inclination of peridental membrane fibers they are always traced from the cementum to the bone, the angle with the horizontal plane being formed at the surface of the cementum.

into the gingiva to support it and hold it closely against the neck of the tooth. These fibers are most numerous on the lingual side, where food is brought against the gingiva with force in mastication and tends to crush it down. In the middle of the gingival portion the fibers pass out at right angles to the axis and are blended with the fibrous mat of the gum on the labial and lingual sides, or are attached to the cementum of the adjoining teeth on the approximal sides. A little farther from the gingival line the fibers are inclined slightly apically, passing over the border of the process to be attached to the outer layer of the periosteum. These fibers are especially large and strong. Just at the rim of the alveolus the fibers are inclined slightly apically and are inserted into the bone, forming the edge of the process.

FIG. 77



Fibers at the border of the alveolar process (from sheep): *D*, dentin; *C*, cementum; *F*, fibers extending from cementum to bone; *Bl*, bloodvessel; *B*, bone. (About 80 ×)

In transverse sections of the membrane in the gingival portion (Fig. 76) the fibers spring from the cementum in large bundles; at the centre of the labial surface they extend directly outward, breaking up into smaller bundles, passing around bloodvessels and bundles of fibers, and blending with the fibrous tissue supporting the epithelium. Passing mesially and distally toward the corners of the root, the fibers swing around laterally and pass to the cementum of the next tooth. On the approximal sides the fibers suddenly divide into smaller bundles, which wind in and out around bloodvessels, and bundles of fibers which pass into the gingiva and are reunited into large bundles to be inserted into the cementum of the next tooth. On the lingual side the arrangement is like that of the labial, except that the distance to which the fibers of

FIG. 78



Transverse section of the peridental membrane in the occlusal third of the alveolar portion (from sheep): *M*, muscle fibers; *Per*, periosteum; *Al*, bone of the alveolar process; *Pd*, peridental membrane fibers; *P*, pulp; *D*, dentin; *Cm*, cementum.

the membrane can be followed before they are lost in the fibrous mat of the gum is usually greater than on the labial.

In the occlusal third of the alveolar portion of the membrane the fibers pass, at right angles to the axis of the tooth, directly from the cementum to the bone. In this position the fibers are large and do not break up into smaller bundles, but the original fibers can be followed uninterruptedly from the cementum to the bone (Figs. 74 and 77). In the middle third the fibers are inclined occlusally, and this inclination increases as the apical third is approached. In the apical third the inclination is greatest, and the fibers as they arise from the cementum are very large and break up into fan-shaped fasciculi as they pass across to the bone. In the apical portion the fibers radiate from the apex in all directions across the apical region and spread out in fan-shaped bundles like those in the apical third of the alveolar portion.

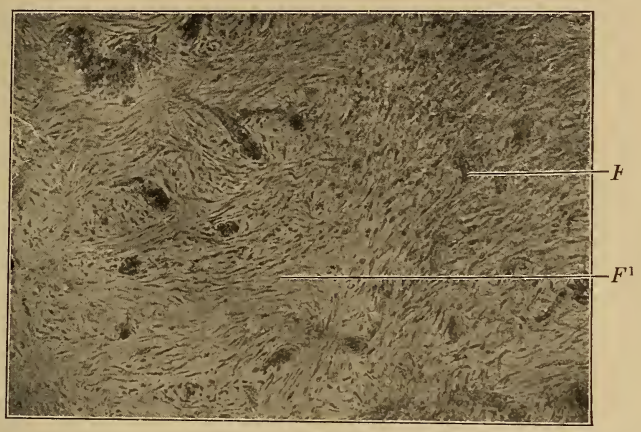
In a transverse section near the border of the alveolus (Fig. 78), at the centre of the labial surface of the root, the fibers are seen to extend directly out from the surface of the root to the bone of the process, excepting where they are diverted to pass around bloodvessels. Passing around distally at the corner of the root, the fibers swing laterally so as to be almost at a tangent to the surface of the root, and are inserted much farther to the distal on the wall of the alveolus. A similar arrangement is noticed at the other corners of the root, though these tangential fibers are usually more marked at the distal than at the mesial corners.

Studying the arrangements of the fibers with reference to the physical function of the membrane, it is seen to be the best that could be devised to support the teeth against the force of mastication and to support the tissues about them. In the gingival portion the fibers passing from tooth to tooth form the foundation for the gingivæ between the teeth filling the interproximal spaces; so that if these fibers are cut off from the cementum, by extending a crown band too far, or by the encroachment of calculary deposits beginning in the gingival space, the gingiva drops down and no longer fills the interproximal space. In the alveolar portion the fibers at the border of the process and those at the apex of the root together support the tooth against lateral strain, while those in the rest of the alveolar portion are so arranged as to swing the tooth in its socket and support it against the force of occlusion (Fig. 73). As seen from the transverse section, the fibers of the occlusal third of the alveolar portion are so arranged as to support the tooth against forces tending to rotate it in its socket.

Cellular Elements of the Membrane.—The *fibroblasts* are spindle-shaped or stellate connective-tissue cells which are found between the fibers as they are arranged in bundles. In sections stained with hematoxylin they take the stain deeply, and the fibers, unstained, are differentiated by the cells lying in rows between them. The number of fibroblasts in the membrane decreases with age. They are large and numerous in the

membrane of a newly erupted tooth, and comparativey small and few in the membrane around an old tooth. This is characteristic of fibroblasts in other positions. The fibroblasts are shown as they appear in a hematoxylin-stained section with low powers in Fig. 79, which

FIG. 79



Fibers and fibroblasts from transverse section of membrane: F, fibers cut transversely; F^1, fibers cut longitudinally, showing fibroblasts. (About 80 ×)

gives part of the membrane in the gingival portion between two teeth. The cells are seen as spindle-shaped dots which mark out the fibers; at F they are seen in a position where the fibers are cut transversely. With higher powers these cells appear as in Figs. 81 and 90.

FIG. 80

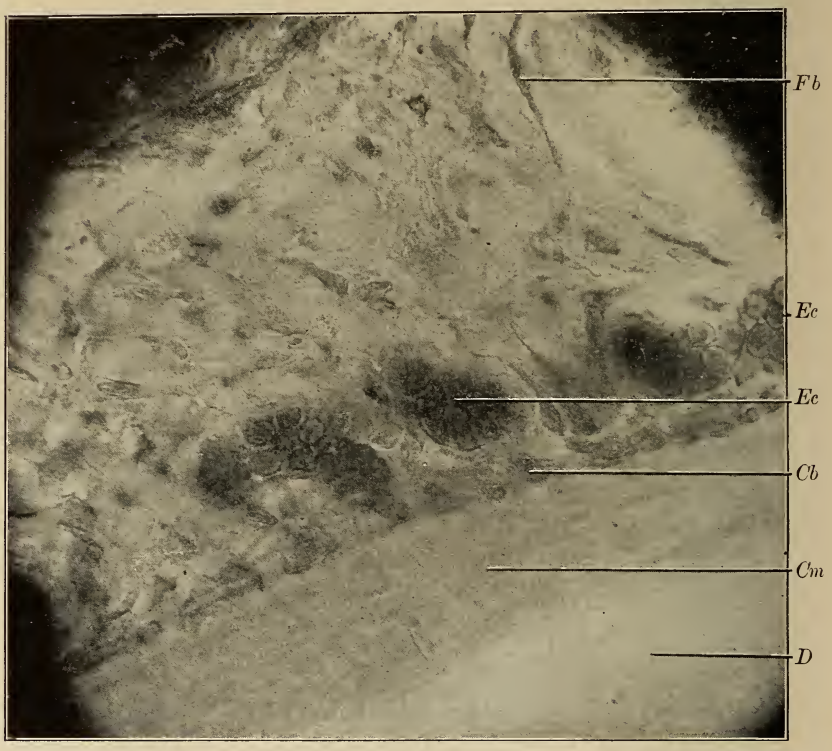


Cementoblasts. (Drawing by Dr. Black.)

The *cementoblasts* are the cells which form the cementum, and are found everywhere covering the surface of the root between the fibers which are embedded in the tissue. While these cells perform the same function for the cementum as the osteoblasts do for bone, they are in form very different from the osteoblasts. The cementoblasts are always flattened cells, sometimes almost scale-like, and when seen from above

are very irregular in outline. This irregularity of outline is caused by the cells fitting around the attached fibers of the membrane so as to cover the entire surface of the cementum between the fibers. Fig. 80, from a drawing by Dr. Black,[1] shows several cementoblasts as seen when isolated by teasing. The cementoblasts have a central mass of protoplasm containing an oval nucleus, and short irregular processes which fit around the fibers as these spring from the surface of the cementum. Fig. 81 shows them in section perpendicularly to the surface

FIG. 81



Transverse section, showing the cellular elements: *Fb*, fibroblasts; *Ec*, epithelial structures; *Cb*, cementoblasts; *Cm*, cementum; *D*, dentin. (About 900 ×)

of the root, where they are crowded between the fibers. The cementoblasts often have processes projecting into the cementum like those from the osteoblast, but processes projecting into the membrane have never been demonstrated.

In the formation of the cementum occasionally a cementoblast becomes enclosed in the formed tissue filling one of the lacunæ, in which position it becomes a cement corpuscle.

[1] Periosteum and Peridental Membrane.

FIG. 82



Border of growing process: *Cm*, cementum; *Pd*, peridental membrane; *Pd.B*, solid subperidental and subperiosteal bone with imbedded fibers; *Ms*, medullary space formed by absorption of the solid bone; *H.B*, Haversian-system bone without fibers; *Per*, periosteum. (About 50×.)

The *osteoblasts* of the membrane cover the surface of the bone, forming the wall of the alveolus, lying between the fibers which are built into the bone. In form and function they are like the osteoblasts in attached portions of the periosteum. They form bone around the ends of the peridental-membrane fibers, building them into the substance of the bone. The bone thus formed over the wall of the alveolus is like the

FIG. 83



Penetrating fibers in bone: *PdM*, peridental membrane; *Ob*¹, osteoblasts of peridental membrane; *Ob*², osteoblasts of medullary space; *PdB*, solid subperidental and subperiosteal bone with embedded fibers; *Ms*, medullary space formed by absorption of the solid subperidental bone with embedded fibers; *HB*, Haversian-system bone without fibers built around the medullary space. (About 200 ×)

solid subperiosteal bone, and is penetrated throughout its thickness by the embedded fibers; but, as with the subperiosteal bone, it is constantly being penetrated by perforating canals, the solid bone being removed by resorption and rebuilt in bone with Haversian systems. This process is shown in Fig. 82, a section through a growing portion

FIG. 84



Osteoclast absorption of bone over permanent tooth: *Oc*, osteoclasts; *B*, bone of crypt wall *F*, fibrous tissue of follicle wall; *A*, ameloblasts. (About 62×)

FIG. 85



Osteoclasts: *Oc*, osteoclasts; *B*, bone. (About 66×)

of the process around a permanent tooth. A higher power (Fig. 83) shows the penetrating fibers and the formation of Haversian-system bone without fibers, in the body of the process.

The *osteoclasts*, or myeloplaques, are bone-destroying cells (Fig. 84); they act not only upon bone, but also upon cementum and dentin. They are oval cells, often as much as 30 microns in diameter, and contain many nuclei—from two or three to fifteen or twenty. They are often called giant cells. The osteoclasts are not constantly found in the membrane, but make their appearance whenever calcified tissues are to be destroyed. In order for them to act upon the tissue they must lie in contact with its surface, and therefore the first step in absorption of the peridental membrane is the cutting off of the fibers embedded in the bone or cementum. Where the osteoclasts act upon the surface of

FIG. 86



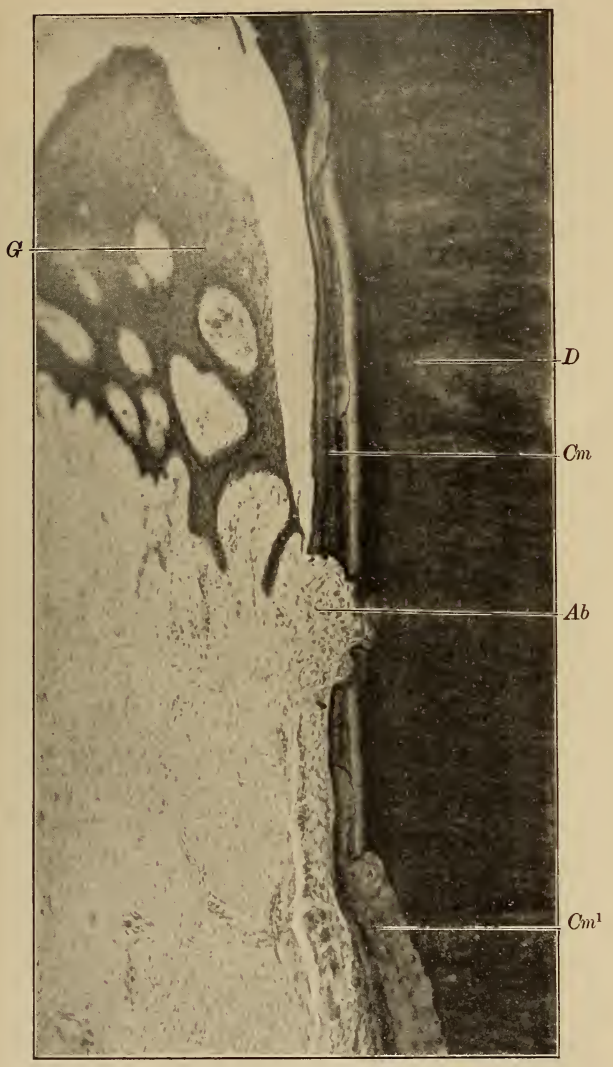
Record in the calcified tissue of an absorption repaired: *D*, dentin; *Cm*, cementum filling absorption cavity. (About 40 ×)

the tissue they produce bay-like excavations, in which they lie, and which are known as Howship's lacunæ. These excavations are shown in Fig. 87, though the osteoclasts have disappeared. In Fig. 86, from a ground section, the basin-like excavations are shown filled with new-formed cementum, thus leaving in the tissue the record of an absorption repaired. In absorption of the roots of the temporary teeth the osteoclasts are found not only in the membrane and attacking the surface of the root, but all through the medullary spaces in the bone, removing the temporary alveolar process.

When absorption is going on at one place on the surface of a root a compensating formation of cementum is going on at another, so that not all of the fibers of the membrane are cut off. This is illustrated by sections of temporary teeth that are ready to be shed (Fig. 87).

Epithelial Structures of the Membrane.—The peridental membrane contains cellular structures of epithelial character which are so con-

Fig. 87



Root of a temporary incisor, showing absorption and rebuilding of cementum (from sheep): *G* gingiva; *D*, dentin; *Cm*, cementum; *Ab*, absorption cavity, showing Howship's lacunæ; *Cm*^{1}, new-formed cementum. (About 50 ×)

spicuous that they demand consideration, though their nature and origin are not as yet fully understood.

These structures were first well illustrated and described by Dr. Black, in his work on the periosteum and peridental membrane, in 1887,

FIG. 88

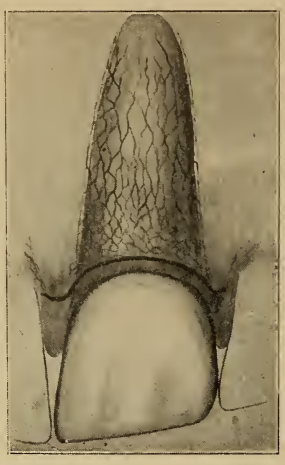


Diagram of glands of peridental membrane. (G. V. Black.)

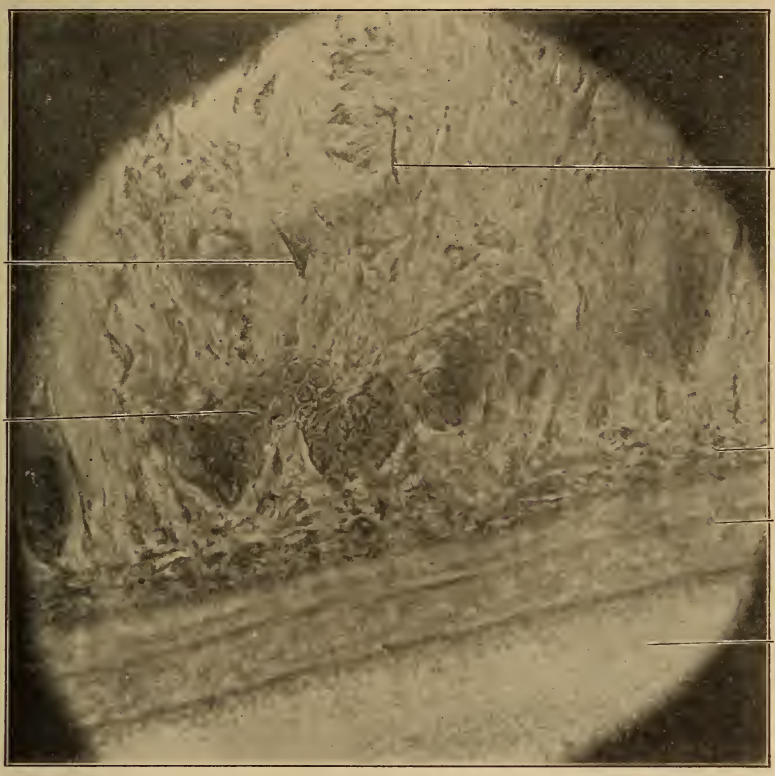
FIG. 89



Epithelial structures of the peridental membrane (from sheep): *Fb*, fibroblasts; *Ec*, epithelial structures; *Cb*, cementoblasts; *Cm*, cementum; *D*, dentin. (About 468 ×)

and were called by him the glands of the peridental membrane. About the same time von Brunn[1] described what are probably the same structures, and which he regarded as embryonal remains of the inner layer of the enamel organ, which he described as growing down over the surface of the root. These structures appear as cords of epithelial cells arranged in the form of a network winding between the fibers of the

Fig. 90



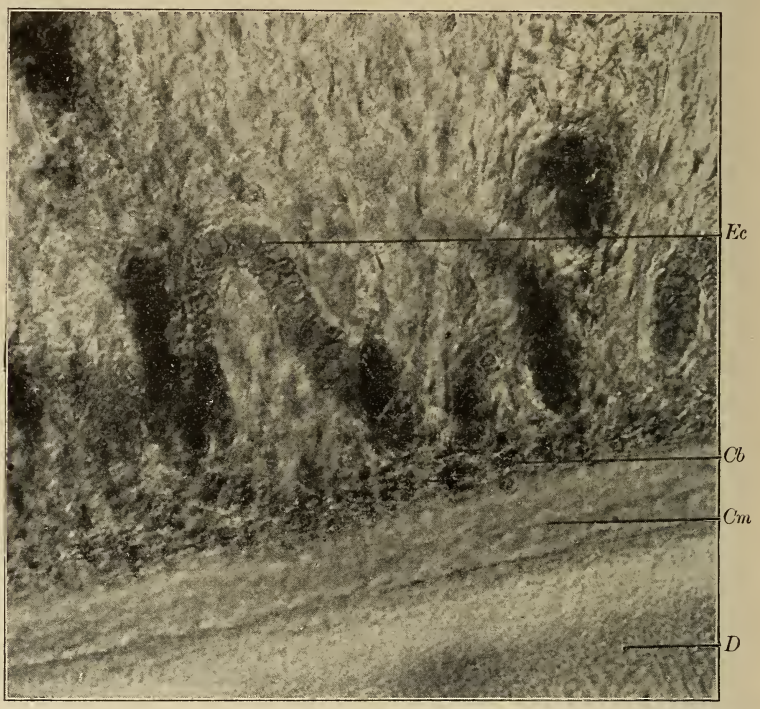
Epithelial structures (from sheep): *Fb*, fibroblasts; *Ec*, epithelial structures; *Cb*, cementoblasts; *Cm*, cementum; *D*, dentine. (About 700 ×)

membrane, very close to the cementum and surrounding the root almost to the apex. Their arrangement is illustrated in Fig. 88, a diagram by Dr. Black. The meshes of the net are close in the gingival portion of the membrane, but grow more and more open in the alveolar portion. They are not confined to the membranes of young teeth or the temporary dentition, as Dr. Black has shown them in the membrane of a tooth from a man, seventy years old, though, like all of the cellular elements of the membrane, they become less numerous as age advances. These struc-

[1] Archiv f. mikros. Anat., 1887.

tures are specially well shown in the membranes of the pig and sheep. Fig. 89 shows their appearance in a transverse section of the root of an incisor of a sheep; here they swing out from the surface of the cementum and back again in loops, winding in and out among the fibers. Studied with higher powers (Fig. 90), they are seen to be made up of epithelial cells with large oval nuclei which react to the characteristic epithelial stains. They are arranged in cords, though sometimes what seems to be a lumen of a gland tubule can be found (Fig. 91). The

FIG. 91



Epithelial structures: *Ec*, epithelial cord, apparently showing a lumen; *Cb*, cementoblasts; *Cm*, cementum; *D*, dentin. (About 500 ×)

cords are invested with a delicate basement membrane, but no special relation to bloodvessels has been demonstrated. The attempt to show their connection with the surface epithelium has thus far failed. As the gingiva is approached (Fig. 92), they seem to swing out from the surface of the root and are lost between the projections of the epithelium lining the gingival space. There is evidence that these structures are, at least in some cases, of importance as the primary seat of pathological conditions of the membrane.

FIG. 92

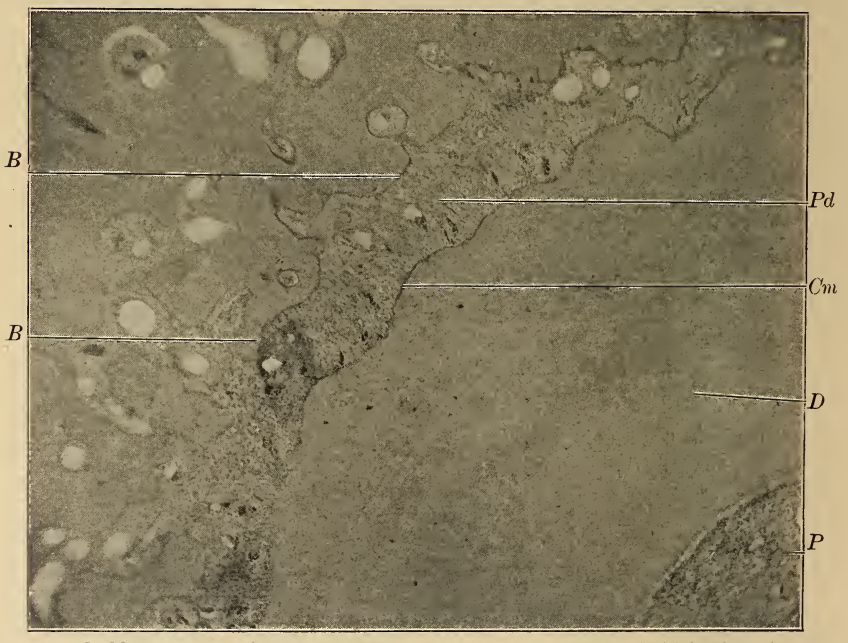


Longitudinal section: *Ep*, epithelium lining the gingival space; *Gg*, gingival gland, so called, *D*, dentin; *N*, Nasmyth's membrane; *Du*, duct-like structure stretching away toward the gingiva from the epithelial cord, seen at *Ec*; *Cm*, cementum, separated from the dentin by decalcification. (About 50 ×)

FIG. 93.



FIG. 94.



Young and old membranes (from sheep): *D*, dentin: *Cm*, cementum; *Cm*¹, thickening of cementum to attach fibers at the corner; *Pd*, peridental membrane; *B*, bone forming the wall of the alveolus; *P*, pulp. (About 80 ×)

Bloodvessels and Nerves of the Membrane.—*Bloodvessels.*—The blood supply of the peridental membrane is very abundant. Several vessels enter the membrane from the bone in the apical region. These arteries branch and divide, forming a rich network, from which the capillary vessels are given off. The arterial network is constantly receiving vessels which enter the membrane through Haversian canals opening on the wall of the alveolus, and in this way the size of the vessels passing occlusally is maintained. Arterial vessels also enter the membrane over the border of the process. This double or triple supply of the membrane is important, as it maintains the health of the membrane when the supply entering through the apical region is entirely cut off by alveolar abscess. While the arterial supply of the membrane is very rich, the capillaries in the membrane are comparatively few. This is, however, a characteristic of connective-tissue membranes.

The *nerves* of the peridental membrane have not been sufficiently studied to be described in detail. Six to eight medullated nerve trunks enter the apical region in company with the bloodvessels, and they receive other trunks through the wall of the alveolus and over the border of the process, but the manner of their distribution and the nature of their endings are not known.

The Changes which Occur in the Membrane with Age.—When a tooth is erupted the roof of the bony crypt in which it was enclosed in the body of the bone is removed by absorption and the crown advances through the opening. The diameter of the alveolus at that time is, therefore, greater than the greatest diameter of the crown, and the peridental membrane which fills the space is very thick. By the formation of bone on the wall of the alveolus and the formation of cementum on the surface of the root, the thickness of the membrane is reduced. In the young membrane most of the large bloodvessels are found in its outer half, forming a rather defined vascular layer near its centre. In the old membrane most of the bloodvessels are found very close to the surface of the bone, often lying in grooves in its surface. Both young and old membranes are illustrated in Figs. 93 and 94, which are taken from the temporary teeth of a sheep, one just after eruption and the other shortly before the time of shedding.

CHAPTER III

ANTISEPSIS IN DENTISTRY

By JAMES TRUMAN, D.D.S., LL.D.

Antisepsis has now become recognized as of vital importance in all operations connected with the human organism. The oral cavity, with its contents, has been considered, of recent years, one of the most important factors in producing disease, and hence both dental and medical practitioners have realized that hygienic and prophylactic measures must begin with this, the vestibule of the entire system. It is here that the pathogenic organisms find a prolific culture field and with the possible result of equally infecting many important organs. That this was not, in earlier dental practice, fully recognized is due to the fact that the part played by bacteria was not known thirty years ago, as it is now, hence cleanliness, as then understood, was held to be sufficient. This, however, will not meet the requirements of the present, and the dental practitioner neglecting to avail himself of all means and appliances necessary to affect antisepsis is assuming a grave responsibility. The skepticism which formerly prevailed as to the value of antiseptic measures had its origin in the prevailing idea that the oral fluids were, with ordinary cleanliness, sufficient to prevent infection.

This has never been proved through laboratory experiments, but clinical observation and long experience have demonstrated that injuries in the mouth ordinarily heal rapidly. It seems unreasonable to suppose that a fluid peculiarly subject to fermentation should have this effect, and this has led some to ascribe it to a vital influence. Miller[1] says of this: "It is a very fortunate provision that the gums in a healthy state offer so powerful a resistance to the invasion of the germs *of most infectious diseases*. For this reason a wound in the gums may be followed by scarcely any reaction whatever, while a similar wound on the hand with the same instrument may produce most disastrous results. It has been attempted to account for this fact on the *supposition that the saliva has an antiseptic action*, in evidence of which we are often reminded that dogs lick their wounds, and that these heal rapidly. . . I doubt if there is anyone who would wish us to believe that the dead saliva has even the slightest antiseptic properties, in consideration of the fact that saliva,

[1] Dental Cosmos, July, 1891.

especially when it contains much organic matter, readily putrefies. If the saliva possesses any such property, it must be sought for in its living histological elements—*i. e.*, in the living leukocytes or phagocytes."[1]

While it is true that there exists a degree of exemption from serious results, leading to indifference and careless management of cases, it is equally true that infection has resulted in the experience of almost every operator in dentistry.

Prior to the period when Lister announced that all operations in surgery should be performed antiseptically, and made modern surgery possible, this ignorance was excusable; but at the present time, with the accumulated knowledge in bacteriology, it should be impossible for any dental operator to neglect the procedures under this head considered absolutely essential for the general surgeon.

The difficulties attending antisepsis in dentistry far exceed those in other branches of surgery. The dentist is necessarily obliged to meet conditions hourly that seem to preclude absolute freedom from sources of contamination. If he were to take the same precautionary measures now regarded as necessary for the surgeon, he would find practice almost impossible. While this is true, it does not follow that every effort should not be made to approach absolute surgical cleanliness.

The usual methods employed to accomplish this, while valuable to a limited extent, are by no means equal to what could readily be secured without consuming much time or patience. The dentist is usually satisfied that he has fulfilled all antiseptic precautions when he has dipped his instrument in some antiseptic fluid, generally carbolic acid. Little or no attention is paid to the possibility of infection from the rubber dam, towels, hands, and the variety of instruments that enter into dental operations. Some of the latter, as, for instance, the separator, are more liable to carry infection than the excavator, the one generally regarded as most important.

The appliances ordinarily in daily use are the rubber dam, excavators, broaches, pluggers, clamps, ligatures, separators, drills, handpieces, napkins, and forceps. It is safe to assume that but few of these will receive any attention beyond ordinary washing. The rubber-dam is too often used as it is furnished by the manufacturer. If an attempt at cleanliness is made, it consists in washing the dam in cold or warm water, this being regarded as sufficient.

The boiling of the rubber in water has the effect of reducing the absolute tenacity of the material. The continuation of the boiling for fifteen minutes, while it does not seem to affect immediately the elasticity, renders the rubber apt to tear, a very objectionable feature. If kept for a few days it deteriorates rapidly. The writer has tested

[1] For an elaborate study of this problem see Experimental Study of the Different Modes of Protection of the Oral Cavity against Pathogenic Bacteria, by Arthur C. Hugenschmidt, M.D., Dental Cosmos, xxxviii, p. 797.

this at various periods of boiling without any marked difference in results. The boiling of rubber cannot, therefore, be recommended. This is to be regretted, for it is evident that the rubber, as it comes to the dentist in sheets, is a very unsafe material to place in the mouth. To meet this objection there remains but one remedy, and that is thorough washing in water with a good antiseptic soap. This has no injurious effect on the material, but while this is true, it cannot be regarded as effective sterilization, but with other aids may answer the purpose.

The dam should never be applied without first bathing the gingivæ of the teeth to be covered by the rubber with a good antiseptic wash. The most effectual is, probably, a 1 per cent. alcoholic solution of hydronaphthol. Upon the removal of the dam this bathing should be repeated, saturating thoroughly the free margin of the gums. This is especially required after the use of ligatures and clamps.

It is needless to add that the rubber should never be used a second time on a different patient.

When it is remembered that this is passed between teeth and usually forced up under gingival margins with ligatures, or clamps, frequently lacerating the surface, it becomes evident that the possibility of infection is always present. If infection does not occur from the rubber, it is almost certain to produce a wound in a locality extremely favorable for the growth of pathogenic germs. The result is innumerable lesions that may extend to pericemental inflammations. The great increase in the past twenty-five years of gingival inflammations subsequent to operations in mouths of more than ordinary health must be partly ascribed to this cause.

Excavators ordinarily receive the most attention, and yet, when their use is considered, they possibly require the least. It is rarely necessary to use the excavator outside of a cavity, where infection, if at all possible, would do the least harm, for the continual washing of the cavity, as the operator proceeds, reduces the danger to a minimum. Broaches and all instruments intended to enter the pulp canals, require the most careful attention, and this applies with equal force to drills; yet it is feared that both of these, loaded though they are with septic matter, receive but indifferent care. When the dangerous possibilities which may result from this negligence are considered, it becomes a serious, if not a criminal offence. The difficulty in making these instruments germ-free and in keeping them from becoming contaminated is fully appreciated; yet the effort must be made, and it is not a difficult procedure, nor does it require a large consumption of time—an important item to the dental operator.

Pluggers cannot be regarded as a source of infection. They are used solely in connection with metal, and therefore strict cleanliness is all that is absolutely required. It is fortunate that this is so, for these instruments require unusual care to protect them from rust.

Hence immersion in an antiseptic fluid may be deleterious and not required.

Separators—and under this head are included metal ones with screw attachments and wedges—require special attention, but probably receive the least. They should be made as nearly sterile as possible before their use upon a patient.

Hand-pieces, of the various kinds in use, are probably the most difficult to keep thoroughly clean. While they do not come in direct contact with the tissues of the mouth, they may indirectly, by contaminating the hands, produce unpleasant results. Frequent taking apart and boiling are essential, and should not be omitted.

Napkins from the ordinary wash have been and are used with confidence that no bad results from use can follow. If the laundry is confined to the home, this may ordinarily be true, but the indiscriminate mingling of washes indulged in by the commercial laundryman is always a menace to health. Where napkins of the latter character are to be used they should be subjected to the sterilizing process.

The chair occupied by a variety of patients may be a source of disease, and should be carefully cleansed, especial care being taken with the head-piece. The latter should be covered with a clean napkin, to be changed for every patient.

The cuspidor, where the fountain is not used, is ordinarily an abomination, for here, if anywhere, will carelessness be manifest. There can be no excuse for this, as thorough daily scalding with boiling water and the use of antiseptics will keep it measurably free from unpleasant consequences.

Glasses require to be thoroughly boiled both before and after use. Boiling should never be neglected with ejector tubes, either metal or glass, glass being generally used. Hard boiling in water for twenty minutes should be sufficient.

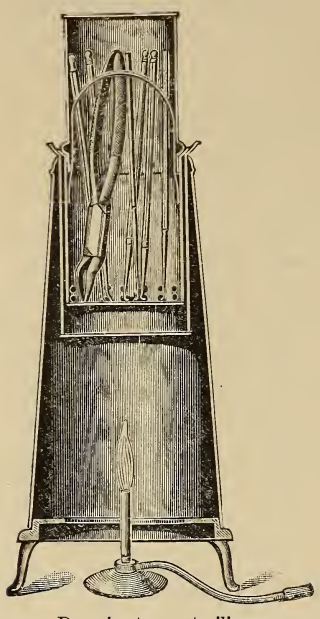
The lancet is an instrument demanding especial care, as it may become a dangerous source of infection.

This instrument should be thoroughly sterilized by boiling in water in which sodium bicarbonate has been added. This must never be neglected, mere dipping in carbolic acid, or a milder antiseptic, has very little value.

The fact that the lancet must frequently be employed on infants during the eruptive stage of the deciduous teeth, demands special care, and before attempting its use the gums should be thoroughly washed with an antiseptic of a non-escharotic character. The difficulty attendant on lancing these teeth in private families, where this is generally required, can be in a measure overcome by the preparatory boiling process in the office and careful wrapping the blade in antiseptic cotton, and, before its final use, dipping it in an antiseptic solution, 1 per cent. solution of formalin preferred.

The forceps employed in extraction should be so constructed as to render the blades readily separable at the joint, and they should be boiled in soda bicarbonate solution for an hour. The recorded cases of infection from these instruments render this care imperative in all instances.

Fig. 95



Downie steam sterilizer.

Fig. 95 shows a convenient form of apparatus for sterilizing ordinary dental instruments by a boiling soda solution.

The writer has found that a half to a teaspoonful of sodium bicarbonate to a pint of water, and kept at boiling temperature for fifteen minutes, is amply sufficient for sterilization and with no injury to instruments. The amount of sodium bicarbonate to be used will depend on the character of the water in a given locality.

Abbott[1] in his valuable chapter on sterilization, thus briefly describes those agents which will "prove of value in rendering infectious materials harmless; they are: Heat, either by burning, by steaming for from half an hour to an hour, or by boiling in a 2 per cent. sodium carbonate solution for fifteen minutes; 3 to 4 per cent. solution of commercial carbolic acid; milk of lime and a solution of chlorinated lime containing not less than 0.25 per cent. of perchlorine." It must be evident that the only available method, in this list, for the dentist is by boiling in sodium carbonate solution.

ORAL DISEASES AND THEIR TRANSMISSION

The possibility of carrying disease from one person to another seems so self-evident that it ought not to require more than a word of caution, and yet it is clear that the attention given to this source of danger is by no means commensurate with the risks assumed constantly in practice. The peculiarly transitory character of much of dental practice precludes the possibility of any previous history of patients, and therefore every one should be regarded as a possible source of infection.

Diseases the result of pathogenic bacteria independent of possible external infection are now in the main well understood, but by no means equally appreciated by medical practitioners, nor are they properly considered by dental operators. Miller[2] states that "many facts favor the

[1] The Principles of Bacteriology, 1902.
[2] The Microörganisms of the Human Mouth, page 275.

supposition that a considerable number of pathogenic microörganisms may thrive in the juices of the mouth without showing in their vital manifestations any distinction from the common parasites of the oral cavity as long as the mucous membrane remains intact. If, however, the soft tissues have been wounded, as in extraction, or if the resistance of the mucous membrane has been impaired, these organisms may gain a point of entrance and thus become able to manifest their special actions." This fact, now well recognized, is being constantly demonstrated in the use of the various appliances that may, through careless handling, injure the mucous membrane. So much is this the case that a large proportion of gingival inflammations have undoubtedly had their origin from this cause. It has come under the observation of the writer that injuries thus received, although apparently unnoticed by dentist or patient, have resulted in the course of forty-eight hours in very disturbing pericementitis, confusing to the operator and very painful to the patient. The necessity for such antiseptic precautions here as are taken in general surgery is almost entirely overlooked. Before placing the coffer-dam, the clamp, or ligature, that portion of the mouth should be thoroughly washed with an antiseptic solution and an effort made to render the appliances equally sterile, or at least to inhibit development for a definite period. (See Treatment of Rubber Dam.) The evidence is abundant that many cases of pyorrhea alveolaris have had their origin from this careless indifference to accepted and necessary precautions.

The mouth, as a source of disease to the general system, does not properly belong to this article to discuss, but its importance cannot be overlooked. Dental writers have devoted much attention to this subject. It is for the dentist to understand that he is, to a large degree, responsible for the general health of his patient as far as the mouth is concerned, and he should insist on prophylactic measures that will at least reduce this source of disease to a minimum. The constant danger of what Miller aptly calls "auto-infection" from the collection and propagation of pathogenic bacteria in the fluids of the mouth should suggest to the dentist constant efforts to effect the removal of all deposits on the enamel, gingival margins, tongue, and mucous membrane. This line of study will bring about in the future an entirely different dentistry as to hygiene and prophylaxis from that practised at the present time.

The pulp of a tooth is not ordinarily regarded as a point of infection, and yet it is well known to be a serious menace to the health of an individual. Israel, quoted by Miller,[1] asserts that "the root canal furnishes a point of entrance even for the ray-fungus, actinomyces, and in one case the microscopic examination revealed the elements of this organism in the canal of a pulpless tooth." When it is considered

[1] The Microörganisms of the Human Mouth, p. 285.

that some individuals have decomposed pulps in a number of teeth at the same time, and frequently a score of dead and broken roots, sending out their infectious material, it is not surprising that disease of a serious nature may supervene. While there is no record of cases coming within the observation of the writer of pulps producing pyemia directly, it is a well-known fact, supported by a long list of recorded cases, that alveolar abscess, with its concentration of putrid material, is liable to be followed by blood poisoning.

There is no question that diseases of the digestive organs, of the lungs—in fact, of all the organs of the body—may be produced by infected material germinated in the mouth, and, indeed, through sputum ejected, may affect individuals remotely situated.

Miller,[1] in considering this portion of the subject, says: "We know that under certain circumstances saccharomycetes may directly colonize in the mucous membrane of the mouth, and that in the mouths of enfeebled individuals bacteria may occasionally obtain a foothold. The mucous membrane of the mouth and pharynx is especially susceptible to the action of certain germs of infection (those of diphtheria, syphilis, etc.), and large portions of the mucous membrane and the submucous tissue may be wholly destroyed by parasitic influences."

The extended use of fixed dentures in the mouths of patients, of so-called bridge-work, and crowns of varied character, are prolific in mouth disorders. The removable bridge-piece, in a measure, overcomes liability to infection, provided the patient is properly instructed in its use and care, but the average patient has no real conception of the danger from infection from this source. It becomes the duty of every dentist, upon inserting such a piece, to insist on careful antiseptic methods of cleanliness.

There is a phase of this subject that requires more extended investigation. Inflammations of the mouth are not infrequent where great swelling is present. This may be observed around the lower third molars with no explainable cause in dead pulps, overlapping mucous membrane, retarded eruption, or malpresentation. It is evidently produced by bacterial invasion, but has not always yielded to antiseptic measures, and at times has resulted in abscess entirely independent of pulp devitalization.

Crowns improperly placed are a continued source of disease, resulting not only in the loss of the roots upon which these are placed, but in gingival and peridental inflammations, involving not only local pathological conditions, but extensive gastric disturbance.

A recent report of three cases by Dr. John A. McClain[2] in the medical practice of Dr. M. G. Tull is interesting as indicating possibilities. The first case was an extensive swelling posterior to the lower third

[1] The Microörganisms of the Human Mouth, p. 295.
[2] International Dental Journal, October, 1900.

molar. He could not connect it with that tooth, and suspected auto-infection. He had cultures made with negative results. His theory was that it was diphtheritic; and, although laboratory evidence was wanting, he determined to inject antitoxin. This injection was followed in twenty-four hours by an entire reduction of the swelling. All other efforts had previously failed to effect any result. Two other similar cases yielded to the antitoxin treatment in the same speedy manner. If this can be regarded as something more than a coincidence in practice, it may lead to an explanation of many similar anomalous pathological cases arising posterior to the third inferior molar, yet apparently not connected with it. Similar conditions have been the cause of much uncertain diagnosis and still more empirical treatment.

The more the writer has considered this subject the more important it has appeared; and he is convinced that, when the proper prophylactic measures come into use for the prevention of tuberculosis, in all its protean forms, antisepsis of the mouth will be given primary importance.

The fact is very apparent that very little attention is given to antisepsis of the mouth in hospital treatment, and what is equally remarkable, our health authorities, in all cities in this country, have not until recently awakened to its importance in connection with the public schools. The authorities are usually quite sufficiently active as to the general health of the children, but pay not the slightest attention to the condition of the mouths and necessary dental care. When this care is given one of the open doors to tuberculosis will be closed.

INFECTION FROM MOUTH TO MOUTH

Infection from mouth to mouth through instruments is a difficult matter to prove by cases, but theoretically there can be no cause for disputation. The question will always arise, Was the lesion occasioned by auto-infection or by transmission? The answer can rarely be given with the assurance desirable. In one instance, at least, in the writer's experience the origin was clearly traceable. This was in a patient of the better class, presenting for treatment in the clinic of the Dental Department of the University of Pennsylvania. Her teeth were remarkable for structure, regularity, and cleanliness; gums perfectly healthy. Necrosis of the anterior alveolar plate was threatened when first seen, and finally resulted in the entire destruction of the alveolar border and all the anterior upper teeth, but did not involve the maxilla. The history of the case as given was that a bicuspid had been extracted from the right superior region by a dentist notorious for his uncleanly habits. Not long thereafter the patient noticed a serious inflammation. These symptoms indicated a syphilitic infection, and the family physician was consulted, who insisted that no history of this disease existed and that

infection must be the cause. The patient, through his treatment and that given locally, recovered, but was forced to wear an artificial substitute.

Cases of infection through extraction, either by the forceps or after-infection from the mouth, might be quoted almost indefinitely. Miller reports case upon case—in fact, the accumulation of these has become of serious moment; and yet, in the face of undisputed facts, dentists will continue to extract teeth frequently without any precautions, or, at most, relying on simple washing of the instrument. Some German writers contend that antisepsis after extraction is wholly unnecessary, as the clot formed is a sufficient protection. This is certainly not true in all cases. It is not always the fact that a clot is formed, or when formed that it serves an antiseptic purpose. One of the most serious cases that has fallen to the writer to treat was that of necrosis of the superior maxilla involving destruction of the right side, taking in all the teeth from the third molar to the lateral, the floor of the antrum, a portion of the nasal bones, and half of the hard palate. This was the result of the extraction of the third molar by a specialist before the days of antisepsis; whether it was the result of infection is difficult to determine. In the opinion of the writer, no extraction should be attempted until the instruments used have been thoroughly sterilized by boiling. Before the forceps are applied the parts surrounding the tooth should be well washed with an antiseptic solution. After the extraction the socket should be syringed with sterilized water, followed by some powerful disinfectant. In view of the serious results probable in this operation there is no longer any excuse for injuries resulting from infection, and a suit for malpractice could be well sustained against an individual who had failed to observe the well-understood methods of antisepsis, while no intelligent practitioner could conscientiously appear on behalf of the defendant.

EXTERNAL INFECTION

The danger to the operator from external infection from instruments is a constant menace; the constant use of these with general freedom from serious results, however, leads to a degree of carelessness not warranted by the ever-present danger from wounds. There is more real danger to the operator from this source than to the patient. All the excavators, drills, and broaches are hourly in contact with infectious matter, and it requires but a slight wound to produce any of the possibilities of blood poisoning. The operator should be on constant guard in this respect, upon the slightest abrasion immediately taking measures, to destroy all possibility of infection from germs that may have been introduced into the wound. This should at once be carefully washed

and an escharotic employed, burning the parts. For this purpose zinc chlorid or carbolic acid are probably the best agents to use, followed by an antiseptic. The latter should be frequently renewed. Experience has demonstrated the value of turpentine in the various mechanical shops where this agent has been for many years in common use for wounds from rusted iron, the possibility of trismus resulting from such injuries being well understood. The writer has used this agent, after burning the wound, almost to the exclusion of other antiseptics.

An illustration of the ever-present danger from wounds occurred to a friend of the writer's, one of the many young women who have graduated in dentistry in this country. She accidentally wounded her hand by a drill, and regarded it as of no moment. The result was severe blood poisoning that for two years kept her hovering between life and death. After suffering from severe metastatic abscesses, she was finally restored to partial health, but with her constitution shattered and her practice ruined for the time being.

IMPLANTATION AND TRANSPLANTATION

Previous to the recognition of the importance of antisepsis, the dentists of that period had a very natural objection to reimplanting teeth; the practice of transplantation was then practically an unknown operation. The danger of the operation was appreciated, but the reason was not then comprehended. When the study of bacteriology had advanced to a science through the labors of Pasteur, Koch, and a host of investigators, the reasons for this fear were explained, and the conditions necessary to avoid unpleasant results being understood, the danger from infection was changed to absolute security. It is, moreover, to be ever borne in mind that but for this knowledge implantation and transplantation could today not be practised without the probability of serious results.

A case illustrating this point occurred prior to the knowledge of antisepsis in the hands of a well-known dentist. He had removed three teeth and successfully reimplanted them for the cure of a violent case of neuralgia presumably due to calcific depositions in the pulp and about the external portions of the roots. Relief was so immediate that upon return of the pain another tooth was attempted. Trismus followed, resulting in the death of the patient. It is safe to assume that this unfortunate result could not have happened under the antiseptic care usual at the present time, even imperfect as it frequently is.

To accomplish antisepsis in this operation the greatest care is necessary. In transplantation, teeth being procured from other mouths, the danger is necessarily much increased. The method, adopted by some, of immersing these teeth in various antiseptic fluids cannot be

commended. Miller[1] says of this: "It is generally accepted that the operator takes every possible precaution when he allows the tooth to lie for one-half to one hour in a 1 per cent. solution of carbolic acid, or in a 1 to 1000 solution of bichlorid of mercury. . . . In order to reach bacteria that may have penetrated into the lacunæ or chance vascular canals, a much longer action of the antiseptic is necessary, and to be perfectly certain that we have accomplished our object we should have recourse to boiling water."

AGENTS USED FOR STERILIZATION

The necessity for a definition of the words used in sterilization may not be apparent to the average reader, but, nevertheless, there seems to be a wide difference of opinion in the use of the terms germicide, disinfectant, and antiseptic. It is evident that these three cannot have a synonymous interpretation, but they are frequently used as meaning death to bacteria. Abbott[2] defines these terms as follows:

"An antiseptic is a body which, by its presence, prevents the growth of bacteria without, of necessity, killing them; a body may be antiseptic without possessing disinfecting properties to any very high degree, but a disinfectant is always an antiseptic as well.

"A germicide is a body possessing the property of killing bacteria."

The possibility of injuring instruments has deterred dentists from using many of the agents recommended for the purpose of sterilization.

Miller[3] made tests of various agents with indifferent results, with the exception of carbolic acid, trichlorphenol, and mercury bichlorid. The list tested included the following:

Carbolic acid in 5 per cent. aqueous solution and in pure form.

Lysol in 5 per cent. aqueous solution.

Trichlorphenol in 5 per cent. aqueous solution.

Sublimate in 5 per cent. aqueous solution; also in the strength of 1 to 1000 of water.

Benzoic acid in the strength of 1 to 300 of water.

Potassium permanganate in 5 per cent. aqueous solution.

Resorcin in 10 per cent. aqueous solution.

Hydrogen peroxid in 10 per cent. aqueous solution.

Saccharin in concentrated alcoholic and aqueous solution.

β-naphthol in 5 per cent. alcoholic solution.

Pyoktanin in concentrated aqueous solution.

Absolute alcohol.

Antiseptin in 5 per cent. aqueous solution.

Zinc sulfate in concentrated aqueous solution.

The essential oils in 5 per cent. emulsions and in pure form.

[1] Dental Cosmos, July, 1891.

[2] The Principles of Bacteriology. 1909.

[3] Dental Cosmos, July, 1891, page 520.

The three previously named, carbolic acid, trichlorphenol, and mercury bichlorid, were the only ones that gave any satisfactory results, and these only partially so. In regard to the rest, Prof. Miller says: "They all fall far short of those already mentioned. The 10 per cent. solution of the *peroxide of hydrogen* came next to carbolic acid, but is considerably inferior to it. The *essential oils*, in emulsions as well as in pure form, utterly failed to produce the desired action."

The results obtained by Miller are not wholly in accord with those of some others. Charles B. Nancrede, M.D., in an article[1] gives a list of agents which have "proved most reliable clinically, can be resorted to in any emergency, or are peculiarly applicable to meet exceptional indications:"

	Marked inhibition.	Complete inhibition.
Mercuric chlorid	1 to 1,600,000	1 to 300,000
Oil of mustard	1 to 333,000	1 to 33,000
Thymol	1 to 86,000	
Oil of turpentine	1 to 75,000	
Iodin	1 to 5,000	1 to 1,000
Salicylic acid	1 to 3,300	1 to 1,500
Eucalyptol	1 to 2,500	1 to 1,251
Borax	1 to 2,000	1 to 700
Potassium permanganate	1 to 1,400	
Boric acid	1 to 1,250	1 to 800
Carbolic acid	1 to 1,250	1 to 850
Quinin	1 to 830	1 to 625
Alcohol	1 to 100	1 to 12.5

At the time these tables were prepared one agent not mentioned was practically unknown as an antiseptic—formaldehyd, or in solution known as formalin.

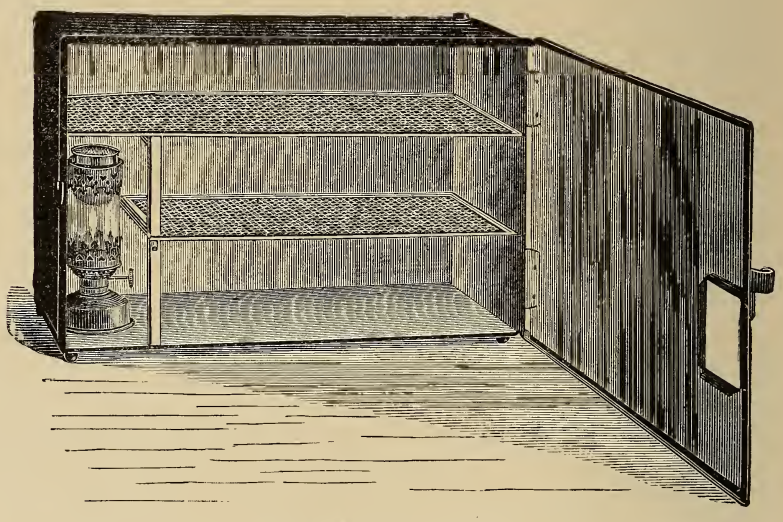
Dr. Elmer G. Horton, B.S., assistant in bacteriology, Department of Hygiene, University of Pennsylvania, undertook, at the request of Dr. Edward C. Kirk, a series of investigations with formaldehyd,[2] the results of which are given, omitting the details of experiments.

"We employed the gas generated by heating over an alcohol lamp a pastil which contained five grains of paraform. The lamp was placed in a tin box of nearly one cubic foot capacity . . . (Fig. 96). Among the instruments employed in the tests were various chisels, excavators, and burs. These were boiled, shown by cultural method to be sterile, then either dipped into bouillon cultures or infected from selected cases found in the operative clinic of the Department of Dentistry, University of Pennsylvania. After infection each instrument was placed in a sterile tube and kept at incubator temperature (37.5° C.) for three hours . . . In a single test with moist instruments we found sterilization complete. After the infection and subsequent drying the tubes containing the infected instruments were separated into two lots, one to be subjected to the method of disinfection and the others to be kept as controls, by

[1] Treatment of Wounds: Antisepsis and Asepsis, Surgery by American Authors, Park, page 365.
[2] Dental Cosmos, July, 1898.

which would be shown that no step other than the action of formaldehyd destroyed the vitality of the germs. . . . After exactly ten or fifteen minutes, according to the experiment, the door was opened and the instrument quickly removed. . . . Each instrument (controls likewise) was placed in a considerable amount of sterile bouillon and these cultures, together with the subcultures made from them, observed for at least one week. . . . In all experiments a free growth developed from the controls. . . . The disinfection of instruments purposely infected in the clinics from cases of caries, pyorrhea, and gingivitis was satisfactorily accomplished in every case. . . . We concluded that infected dental instruments can be disinfected without injury in a closed

Fig. 96



Schering's formalin sterilizer.

space of less than one cubic foot, by an exposure of fifteen minutes to the formaldehyd gas generated from a pastil containing five grains of paraform by heating the pastil over a proper alcohol lamp."

In an article on the "Uses and Limitations of Formaldehyd in Dentistry," by Dr. F. W. Low, Buffalo, N. Y.,[1] the effect of formaldehyd gas is further given as shown by a series of experiments conducted by Dr. Thos. B. Carpenter, assistant bacteriologist to the Health Department of the City of Buffalo. Without entering into detail, the experiments consisted of two series, one of infected instruments and the other of clothing either of school children, of nurses, or of the doctor in the presence of contagion, to determine whether they could be thoroughly sterilized by placing them over night in a wardrobe exposed to the fumigation of the lamp used.

[1] Dental Cosmos, February, 1900.

The conclusion of Dr. Carpenter was that "This apparatus can be relied upon, after an exposure of from ten to fifteen minutes, to destroy thin layers of the common, non-sporulating pathogenic organisms."

In regard to the second series of experiments with clothing, he says: "It is evident, therefore, that twelve hours' exposure to the action of this lamp in a closet 15.8 cubic feet capacity is sufficient for effective surface disinfection, the most resistant pathogenic bacteria being destroyed."

A third series of experiments was undertaken with scaling instruments taken from the instrument cases from several operators, including that of Dr. Low. The result of this elaborate experimentation is thus summed up by the author: "Every set, *except the one where the whole case was fumigated* over night, produced some cultures; but not one set developed a culture of pathogenic organisms."

"The Low lamp consists of an asbestos-lined tray, or box, supported on legs (Fig. 97, *A*), with an opening in the bottom to admit the chimney of the lamp, the purpose of which is to conduct the fumes of the formaldehyd gas into the tray and upon the instruments it is desired to sterilize.

"The working parts of the lamp are shown in the illustration. An ordinary alcohol wick is drawn into the wick tube. To place the lamp (*B*) in operation, fill it with *wood* alcohol, grain alcohol being incapable of generating formaldehyd. Adjust the cone-shaped platinum coil so that it just touches the top of the wick. Light the latter; place on chimney, and after a few seconds' waiting blow out the flame. If the cone be in proper adjustment to the wick, it will be observed that the coil glows like a live coal, but there is no flame or dangerous heat.

"Having the lamp in operation, as described, and the tray properly adjusted to set over it, as in the illustration, instruments may be placed in the tray and allowed to remain for ten minutes, a sufficient time to effect sterilization. When taken out they should be wiped dry with a *surgically clean* napkin or towel.

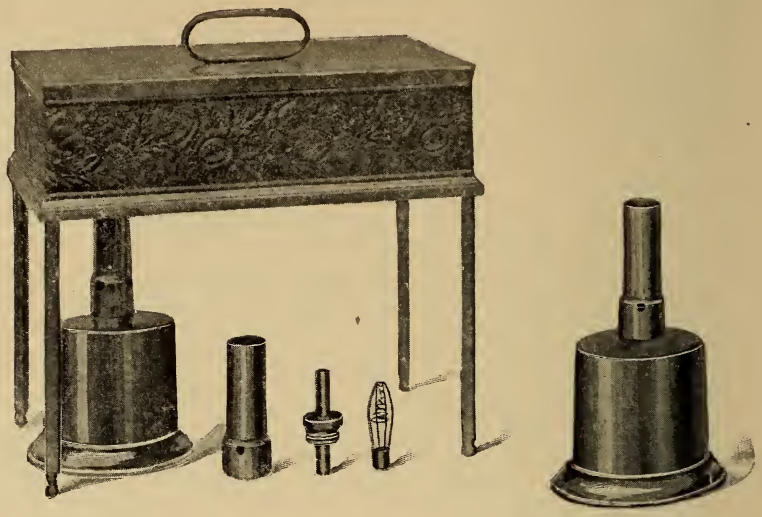
"To stop the fumigation going on in the lamp, remove the chimney and slide the cage high up on the tube, so that the platinum cone no longer touches the wick, then allow it to cool before replacing chimney."

While it is not difficult for the average dentist to use formaldehyd as a disinfectant, it will probably be considered a useless expenditure of time, and, therefore, boiling in water and soda for at least twenty minutes seems the more feasible and is equally certain in the results.

The dentist who aims to keep only aseptic instruments should have two sets in daily use. When through with one patient the instruments should undergo the boiling process in preparation for the next. At the close of the day all instruments used should be thoroughly boiled and dried upon aseptic napkins and placed in the case. The possibility of infection from the latter must not be overlooked. The first and

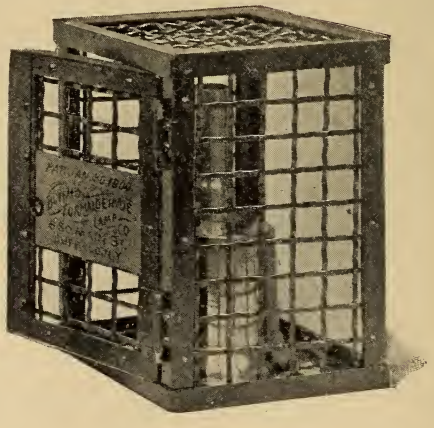
second set, therefore, used the next day for the first time should be either boiled again or each instrument dipped into an antiseptic fluid. For this purpose the writer prefers a strong solution of hydronaphthol (8 grains to the ounce of alcohol) to the carbolic acid solution ordinarily used. With this care all danger of infection can be removed and the

FIG. 97



A B

FIG. 98



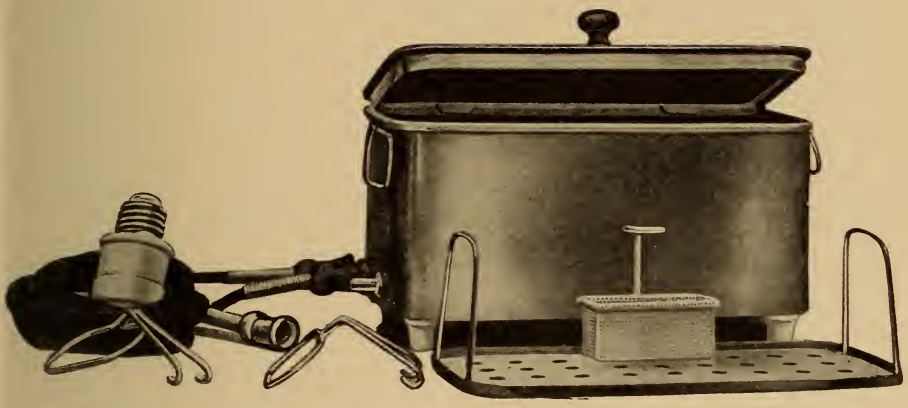
dentist relieved of all legal responsibility. The combination sterilizer and hot-water heater for gas or alcohol, designed by Dr. George J. Paynter, seems to be a convenient arrangement for the office.

Fig. 99 represents a very convenient and efficient sterilizer where the electrical current is established. It sterilizes with boiling water.

The full capacity of this sterilizer is two quarts. It has rounded corners and all seams are eliminated, with the exception of one at the terminal end. This prevents collection of debris, and facilitates cleaning. It is provided with a tray for small instruments, and with nickel-plated hooks for lifting it. The lid is provided with a wooden knob.

It can be run by the direct or alternating current, and will boil water in fifteen minutes. It is made of heavy copper, nickel plated outside and tinned inside. The equipment includes a six foot connecting cord, with terminals and plug. Its efficiency, simplicity, and ornamental character recommends it for the dental office where available. It is introduced by the S. S. White Dental Manufacturing Company.

Fig. 99



The preparation of the hands previous to operations is most perplexing to the conscientious operator, whether this be in surgery or dental practice. In order that dental operators may be able to arrive at definite conclusions in regard to what may be required of them in their daily work, the following quotation is given from Nancrede's article[1] on the care required in hospital surgical practice:

"Sterilized water as hot as can be borne should be employed. This must, of course, be never cooled by the addition of any but cold sterilized water. . . The nail brush, best made of vegetable fiber, must always be carefully rinsed after use and sterilized by heat for each operation. . . Although it is alleged that all soaps made by heat are sterile—indeed, that potash soap is an active germ inhibitor in the proportion of 1 to 5000—yet it is the part of prudence to combine with the soft soap 5 per cent. of hydronaphthol or thymol, to insure that the soap itself is free from germs. After thoroughly rubbing into the hands and arms and under the nails abundance of soap, the nail brush and

[1] Loc. cit.

hot water must be vigorously used, especially beneath and around the nails, for from two to five minutes. Next, carefully clean the nails and around them with a nail cleaner. Removal of all grease can now be effected by ether or by immersion in alcohol, or best by alcohol containing 5 per cent. of dilute acetic acid, which should be rinsed off thoroughly with sterilized water, removing the last traces of soap. Finally, the hands should be immersed—not merely dipped—in a 1 to 2000 mercuric chloride solution for not less than three—preferably five—minutes. Instead of corrosive sublimate solution, ordinary mustard flour mixed in the hands into a thin paste with sterilized water, used with gentle friction for two or three minutes and then removed with sterilized water, will prove a most successful germicide."

While the foregoing may serve as a basis for comparison, it would be wholly impracticable in dental practice. It remains, however, that the hands of the dental operator should be the subject of constant care. Nails should be kept short and scrupulously clean.

The importance of this to the dentist cannot be overstated, and it is probably the one precaution most neglected. The fingers are, necessarily, continually in the mouth of the patient, and nothing disturbs a cleanly person more than ill-kept nails, possibly loaded with infectious matter. Nails should be closely cut and the surrounding tissue well cared for by brush and antiseptic solutions.

It seems to the writer that the use of a good potash soap and nail brush, with bathing the hands in alcohol, will be amply sufficient unless working on a syphilitic patient, when more effective methods must be resorted to, and there can be nothing better than the mode described by Dr. Nancrede.

The conclusions to which the writer has arrived from experience and study of the subject may be summed up briefly as follows:

1. Dipping instruments in an antiseptic fluid previous to operating, while beneficial, is not sterilization.

2. That boiling in water with soda added is for the dentist the most convenient means of sterilizing instruments without injury, while the more recently introduced method of formaldehyd antisepsis is a dry process that does not rust or injure steel instruments and is also promptly effective. The aqueous solution of formaldehyd (formalin, 35 to 40 per cent.) is probably the best agent where simply dipping the instrument is desired. Two per cent. is of sufficient strength.

3. That the ordinary methods used to effect sterilization in surgical practice are not possible in dentistry, but that every dentist is legally and morally bound to live as near to the rules of antisepsis as is possible with the demands of a daily practice.

CHAPTER IV

EXAMINATION OF THE TEETH AND ORAL CAVITY PRELIMINARY TO OPERATION—REMOVAL OF DEPOSITS—APPLIANCES AND METHODS—RECORDING RESULTS

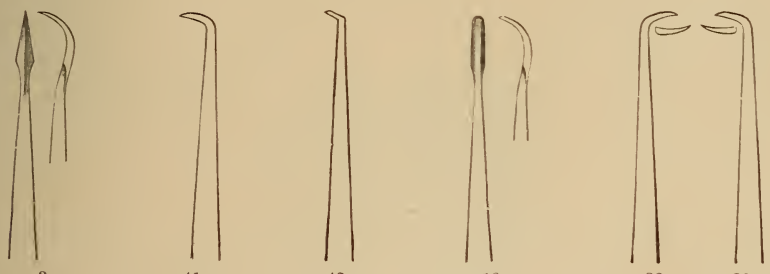
By S. H. GUILFORD, A.M., D.D.S., Ph.D.

Before undertaking the examination of the teeth it will be necessary to remove any calcic deposits that may be found upon the various tooth surfaces in order that every portion of the crowns may be open to inspection and instrumental exploration.

This operation is usually known as "scaling," from the fact that the deposits are generally of a hard consistency, and when force is applied come away in scaly, fractured portions.

The instruments employed are denominated scalers and are furnished in a variety of forms. Those of a sickle shape have met with the greatest favor, their peculiar form enabling the operator to reach conveniently more portions of the tooth surface than would be possible with an uncurved point.

Fig. 100



Scaling instruments.

Some of these are shown in Fig. 100. Frequently, however, a large sized hoe or a spoon excavator will be found to operate more readily and expeditiously where large masses of the deposit are to be removed, as upon the lingual surfaces of the lower incisors and the buccal surfaces of the upper molars.

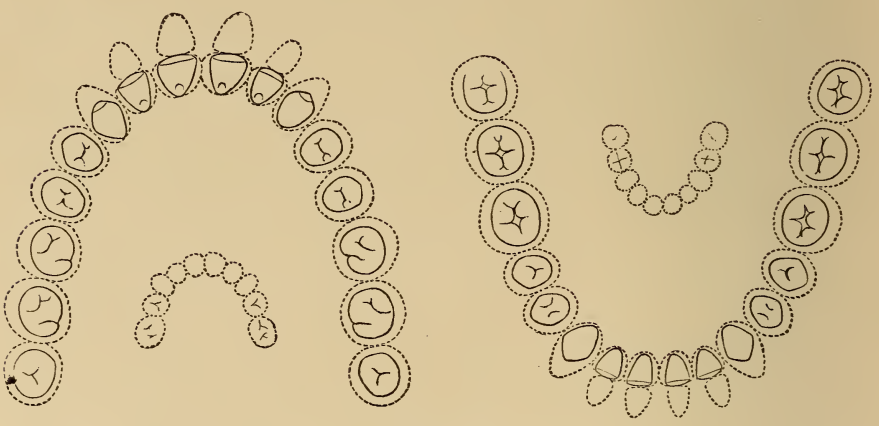
In the removal of the hard deposits from the teeth great care should be exercised to avoid injury to the soft tissues and the infliction of unnecessary pain.

As the deposits usually terminate in an abrupt margin next to the gum, the edge of the instrument employed for removal should be caught above this ledge and drawn toward the occlusal or incisal surface with some force, so as to dislodge as large a portion of the material with each movement as possible. By repeated efforts of this character every portion of the deposit may be removed without tissue injury or bloodletting.

With the exercise of care the operation of scaling need not be painful, except in the case of loosened and diseased teeth, and even then the discomfort may be greatly lessened by steadying with the thumb and forefinger of the left hand each tooth as it is operated upon.

The teeth once freed from deposits, their examination should be proceeded with. The importance of a careful and thorough examination can scarcely be overestimated, for failure to discover even a small lesion might result in subsequent serious consequences. In making the examination, certain instruments and accessories are necessary and should be at hand.

FIG. 101



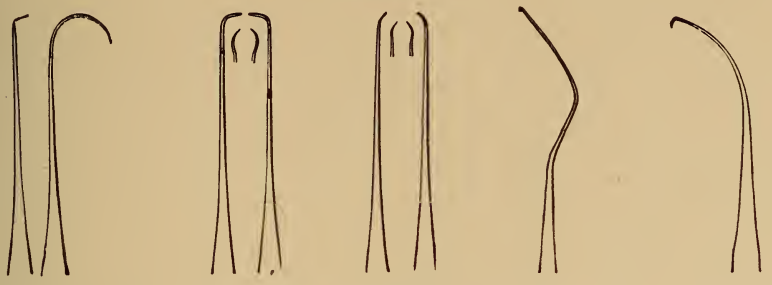
Record chart.

Record Charts.—Charts consisting of a diagram of the teeth may be printed upon ordinary paper and fastened together in tablet form, or they may be printed upon heavier paper, or cardboard, and handled separately. Charts of different design are to be had, but the one shown in Fig. 101, designed by the writer, has answered every purpose; it represents both the permanent and temporary sets of teeth and each arch in its natural position. This enables the examiner to make his record more quickly and easily.

Exploring Instruments.—These are delicate, tapering steel points, with spring temper and bent at an angle near the point. Those designed by Dr. Perry have met with the greatest favor. They come in a number of forms, fashioned into different angles and curves, as shown in Fig. 102.

The explorers are furnished either as solid instruments or as points to be screwed into a cone-socket handle, the latter being preferred because, when broken, they may be easily and quickly replaced. The first two shown in the illustration will serve all ordinary purposes, but the others are valuable in reaching points difficult of access.

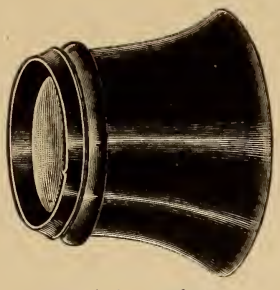
Fig. 102



Exploring instruments.

Mouth Mirrors.—These may be had either with a plain surface, which reflects the image in its natural size, or a concave surface, in which the image is magnified. Some prefer one form, some the other, but the majority of practitioners favor the use of the concave glass, since with the enlargement of the image we have also the magnifying of the defect, which enables it to be more quickly detected.

Fig. 103



Jeweller's eye-glass.

Magnifying Glass.—To obtain a still further enlargement of the object, many operators use a magnifying glass of some form in addition to the mouth mirror. One known as the jeweller's eye-glass, shown in Fig. 103, is probably the simplest and the most convenient form for dental examination. In use it is held between the thumb and forefinger of the left hand, about four inches from the object, and by its magnification surfaces of the teeth may be examined very quickly and accurately. Frequently the mouth mirror, held in the right hand and placed under-

neath the tooth to be examined, throws a light upon the surface in such a way as to illumine it, and with the eye-glass on the opposite side, the illumination and enlargement are complete. By the combined use of the two glasses, cavities or partly disintegrated enamel are discovered which would have been missed by the ordinary means of examination.

Silk Floss.—Silk floss is a very important accessory, as it enables us to detect any lesion or roughness on the approximal surface which has not otherwise been discovered. The silk should not be waxed, for if unwaxed the fraying of its fibers when passed between the teeth serves to indicate any unnatural condition of the surface. If waxed, no fraying would be likely to occur, the wax serving as a lubricant. The strands should not be too light nor yet too heavy; an intermediate grade being the best.

Air Syringe.—An air syringe is a valuable adjunct in removing moisture from any surface of the tooth or between the teeth, thus enabling us to examine the parts more thoroughly.

Absorbent Paper.—Thin Japanese absorbent paper or absorbent cotton, together with delicate tweezers to assist in applying it to different surfaces for the purpose of removing moisture, should also be provided. With all these accessories at hand, the examination may be begun. The patient should be placed comfortably in the chair and the clothing protected by a towel or a large napkin fastened around the neck. A glass of water should be provided and additional hand napkins placed upon the bracket table for the patient's use.

Technique.—The positions where caries is most likely to be found are in the fissures and sulci, and upon the approximal surfaces, the latter requiring the greatest care in examination on account of their difficulty of access. In beginning the examination a general inspection of the mouth and teeth should be made with the mouth mirror, and the visible cavities and defects marked upon the chart with a pencil. The explorer should next be passed over every exposed surface carefully and also under the free margin of the gum. Occasionally cavities are found hidden under the gingival margin which would not be discovered unless revealed by the explorer. In examining the approximal surfaces they should be made as dry as possible with absorbent paper or cotton, followed by a blast from the air syringe thoroughly to dry the surface. The explorer should be introduced into the interproximal space with its point directed toward the occlusal surface; then, by passing it back and forth, every portion of the approximal surface may be examined, excepting the contact point. This should be followed by silk floss, passing it back and forth between the points of contact. Even after the use of the explorer and the silk it is well to inspect these surfaces with a jeweller's glass, for, while there may be no extensive disintegration of the enamel, there may be an altered condition of the surface, as evidenced by discoloration or a chalky appearance near to or at the point of contact, which will be revealed by the use of the jeweller's glass

above and reflecting mirror below. In order that the examination may be orderly and nothing omitted, it is well to follow a definite plan.

We may begin the examination at the median line of the upper arch, examining each tooth successively back to and including the third molar; then, by beginning again at the median line and passing around the other side in the same manner, we will have included all the teeth of the upper arch. The lower arch should then be examined similarly. As cavities or defects are found they should be marked upon the chart, and it is well even to note any disposition toward tooth disintegration that may be met with in the course of the examination. The electric mouth mirror has been recommended as an aid in examination, but it does not seem to be a necessary adjunct. It has its use in determining whether the pulp in a tooth is alive or not, but the mirrors previously mentioned are sufficient for the purpose of detecting any injury to tooth substance.

In addition to marking upon the chart such new cavities as may be found, we should examine the condition of any fillings previously inserted and note whether or not they are fit to remain. If these are defective the fact should be noted upon the chart, and if in the course of the examination places are found where it cannot be definitely decided whether tooth substance has been injured or not, it should be noted for further examination. In addition to marking upon the chart the cavities found, it is well to indicate upon the figure of the tooth the apparent extent of the tooth injury; in other words, the pencil mark should indicate the relative size of the cavity.

If it is desired to indicate at the same time the character of the filling material to be used in the various cavities, it may be done by the use of colored pencils, using a different color for each kind of material to be employed. The advantages of a chart record are various. It shows at a glance the extent and character of the services needed; it forms the basis for the estimating of time required or expense involved; by checking off each item as completed it will indicate the still unperformed operations, and permit the selection at each sitting of such work as is fitted to the time set apart; in addition, it will be of service in showing to the patient the number and character of the proposed operations.

If in course of the examination it is apparent that the patient has not been in the habit of giving proper attention to his teeth, a good opportunity is afforded for instructing him in the matter, and impressing upon him the fact that if the proposed operations are to be lasting and efficient, it is quite important that personal care on his part shall contribute to the desired success.

CHAPTER V

CREATING INTERDENTAL SPACES PREPARATORY TO FILLING; GRADUAL SEPARATION; IMMEDIATE OR FORCIBLE SEPARATION

By S. H. GUILFORD, A.M., D.D.S., Ph.D.

In separating teeth to obtain space for operation upon their approximal surfaces, great care should be exercised to avoid injury to the soft tissues or undue irritation of the pericementum. The operation at best is one which patients dread, on account of the soreness induced in the moving teeth. The teeth of children, either deciduous or permanent, are more easily and quickly separated, owing to the greater thickness of the pericementum and imperfect calcification of the alveolar septa, while the teeth of adults move more slowly and require greater time for their separation because of the lessened thickness of the pericementum and the greater density of the septa. In view of these facts the character of the force to be applied and the means of applying it must be suited to existing conditions. When wedging is very gradual it is accompanied by little irritation, and consequently the soreness is reduced to the minimum. Where it is more rapid the operation is attended with greater irritation and more pain. Various substances and methods may be employed to create interdental spaces; fibrous substances such as cotton, tape, wood, etc., operate by the absorption of moisture and consequent expansion; elastic rubber exerts resilient force and operates rapidly; mechanical separation by steel separators, while limited in its results, is direct in its operation and often very useful as an accessory method.

Gradual Separation.—*Cotton.*—Cotton for separation can be used to the best advantage when a wisp of it is twisted and drawn between the teeth at their points of contact. It should be kept dry while being inserted, and when in place clipped close on the labial and lingual surfaces of the teeth; as its expansive properties are largely due to the absorption of moisture and are limited, it should be renewed each day until sufficient space is gained. The fibers may be constricted and expansion consequently increased by passing a silk ligature through the interdental space between the cotton and gum and around the pledget, then drawing it tight and tying in a knot—this tying of the cotton also serves to keep it in place more securely. A modification of this plan consists in wrapping or twisting the wisp of cotton around a silk liga-

ture. After it has been drawn between the teeth the free ends of the ligature are passed around the mass as in the previous instance, and tied.

Linen Tape.—This substance operates on the same principle as cotton, and is more convenient to handle and place in position. The tape should be thin and very little more than one-eighth of an inch in width; one thickness should be drawn between the teeth the first day, two on the second, three on the third, and so on until sufficient space has been gained. Some operators employ waxed tape for separating, but the unwaxed is preferable because it absorbs moisture rapidly and it is the expansion of the fiber from absorption of moisture that gives it its efficiency. As the tape is easy to grasp and manipulate, patients frequently can insert the subsequent thicknesses themselves after the first piece has been placed by the operator. While both of the foregoing methods of separation are slow, requiring four or five days to produce the desired result, they are almost painless on account of their slowness.

FIG. 104



Wood wedges.

Wood.—Compressed hickory in the form commonly known as pivot-wood, or some softer wood, as bass-wood strips, can be used for wedging. The latter, in order to have its efficiency increased, should be cut into strips lengthwise and then compressed laterally by being passed between the rolls of a rolling mill. In introducing wood of any kind it should be whittled to a wedge (Fig. 104) and pressed firmly between the teeth to be separated. When in place and the protruding portions have been clipped off with a wedge cutter, the rough ends should be smoothed with a small corundum wheel in order to avoid possible irritation of the lips or tongue. Like cotton or linen tape, the wood expands by the absorption of moisture, and as it has been compressed before introduction, its expansion is not only greater but more rapid.

Cork.—On account of its compressibility and rapid expansion in the presence of moisture, cork is an admirable substance for the separation of teeth. The tenacity with which it clings to the tooth surface is another advantage which it possesses, because it is less likely to become displaced than wood. Thin slices of good bottle cork may be used, and after being

introduced between the teeth, should be clipped close with a sharp bistoury. As cork is lacking in strength it cannot be forced between teeth that are close together. A slight space must first be created by the use of some other material, and then the separation continued by pieces of cork of varied thicknesses. Although its operation is slow, cork is one of the least unpleasant substances to use so far as the patient's comfort is concerned.

Elastic Rubber.—This substance operates more quickly in separating teeth than any other material used for gradual separation. Its resiliency is so great that when a strip of it is drawn between the teeth its effort to return to its original form causes it to operate incessantly until this is accomplished. Owing to its constant expansion, the teeth under its influence are rapidly moved apart, and as a result, irritation is often set up in the pericementum, accompanied by soreness of the teeth when touched. Because of its rapid action it is employed far more frequently than any other substance for the separation of teeth, and as the irritation brought about by its use is its only objectionable quality, this may be modified by beginning the separation with a very thin piece. If the teeth to be separated are in close contact, a narrow strip of medium rubber dam may be drawn between them to start the separation; after this has been in place for a day it can be followed by a somewhat thicker piece which may be allowed to remain for two or three days.

A very convenient form of rubber is that known as French rubber tubing. It comes in various sizes, the thickness increasing with the diameter. Sections cut from the tubing and then slitted afford a very convenient means for introduction between the teeth.

According to the writer's experience, the use of elastic rubber should be confined to the first stages of separation, to be followed by the use of cork or tape; in this way teeth may be separated with very little resulting soreness. As rubber is extremely slippery when moist, it is very liable to change its position in the act of separating, and to slip up and impinge upon the soft gum tissue of the interdental space; it has been known to bury itself under this tissue and create great irritation when the patient has remained away from observation too long. To avoid this possibility, when rubber is placed between the teeth it should never be allowed to touch the gum, and at the same time should not be clipped too close to the incisal or occlusal surface.

The same caution should be exercised in the placing of any separating material between the teeth. Whatever substance is employed, we should endeavor to retain it in its proper position by any and every means at our command. At the same time the patient should be instructed to return at once to the office if it be found that the substance between the teeth has become loose or has shifted its position. Should the teeth show symptoms of extreme soreness after separation by any method, it may be relieved before operating upon them by placing some non-

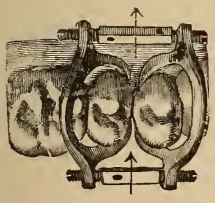
resilient substance like gutta-percha between them and allowing it to remain for a few days. In this way the space will be preserved and the teeth given time to recover from their tenderness.

Base-plate Gutta-percha.—Where large approximal cavities exist, and it becomes necessary to separate the teeth in order that their normal contour may be restored by filling, a very excellent method is to pack the cavities a little more than full with red or white base-plate gutta-percha. By the action of the opposing teeth in closing, the material will be forced farther between the teeth and thus separate them gradually and almost painlessly. This idea originated with the late Dr. W. G. A. Bonwill, who found it of the greatest value and claimed that in addition to separating the teeth, gutta-percha would force the gum tissue beyond the gingival margin and thus expose that portion of the cavity which is usually difficult of access.

Fig. 105

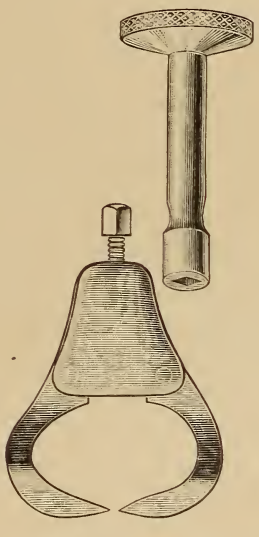


Fig. 106



Perry separators.

Fig. 107



Capwell's "single-bow" separator.

Immediate or Forcible Separation.—The earliest method of producing immediate separation consisted in driving wooden wedges alternately between the teeth at their points of contact and through the interdental space near the gingival margin. It was a crude and painful method, and later was superseded by steel separators acting upon the screw principle. One of the first of this type to be devised was the "double-bow" separator invented by Dr. S. G. Perry. It is shown both separately in Fig. 105 and in position in Fig. 106. The first one of the Perry separators was intended for use between the incisors, but as soon as its value began to be recognized, others of the same form were devised for

use between the side and posterior teeth; thus a set of six was placed upon the market which seem to meet all requirements of an instrument of this character. The Perry separator probably is used today more than any other mechanical separator ever devised. Another form of separator, shown in Fig. 107, and known as the "single-bow," was devised by Dr. G. C. Capwell. While it may be used between any of the teeth, it is more especially serviceable in the anterior part of the mouth. As will be noticed, it is extremely simple in construction, and when in position is well out of the way of the operator. The handle used to operate the screw is removable, which is a feature peculiar to this instrument.

While the mechanical separator is sometimes regarded as a painful instrument on account of its rapidity of action, it really need not be a source of distress to the patient if the operation is not hurried. With one or two turns of the operating screw followed by a rest of a few minutes and this process repeated, a fair amount of space can be obtained in from five to ten minutes' time. It will not usually provide as great a space as that obtained by the slower methods, but a plan frequently followed is to do part of the separating by the slow method of expansion and then at the time of the operation gain a little more space by the use of the mechanical separator. It has also been observed that if the teeth should retain some of their soreness after gradual separation, the application of the mechanical separator and its tightening will immediately relieve such soreness and permit the operation to be performed painlessly.

This is doubtless due to the paralyzing of the nerve fibers of the pericementum under the pressure developed by the rapid action of the screw. The mechanical separator can be used to great advantage in the separation of children's teeth since the greater thickness of the pericementum permits its more rapid compression.

CHAPTER VI

MODIFICATION OF DENTINAL SENSITIVITY BY DEHYDRATION; TOPICAL MEDICATION; ELECTRICAL OSMOSIS; GENERAL ANESTHESIA

By S. H. GUILFORD, A.M., D.D.S., Ph.D.

As all normal dentin is sensitive, the term sensitive dentin is incorrect when used to designate hypersensitive dentin, which may be defined as an exaltation of the normal sensitiveness of dentin. The dentin which comprises the large bulk of the hard tissues of a tooth is covered by enamel on the crown and cementum on the root; therefore, in the condition of normality the only indication we have of the sensitiveness of dentin is that which we experience in the application of substances, usually food, either considerably above or below the normal temperature of the mouth. If, however, the enamel has been removed from a tooth in whole or in part, either by accident, mechanically, or by caries, the dentin is exposed and thus sensitiveness becomes immediately apparent. Normal dentin may become exposed to outside influence through erosion, abrasion, traumatism, or caries. When exposed by erosion or abrasion it may or may not be hypersensitive. Very often hypersensitiveness is observed in teeth where the enamel has been worn away from the point of the cusps or where, through gum recession, the cementum has become exposed and gradually removed by friction. When enamel has been abraded, as by a clasp on a plate, its wearing through to the dentin is so gradual that when the latter becomes exposed it is not apt to be very sensitive; in this case the pulp, stimulated to new activity by the external irritation, has formed new dentin upon the pulpal wall to compensate for that worn away externally by attrition, which accounts for the lessened sensitivity. When a tooth has been invaded by caries there may be no actual exposure of the dentin to the air and other external influences, since the soft products of caries overlie and protect it, thus serving as a non-conductor. In the process of excavating a cavity, when the debris of caries is removed, actual dentinal exposure takes place and the cutting of the dentin in the continued excavation of the cavity is often found to be very painful. In such cases the dentinal fibrillæ may have been exposed to the action of caries-producing influences, generally lactic acid, and become irritated thereby. This is especially true when the progress of caries has been rapid; when it is slower the pulp has opportunity to protect itself from irritating

influences by the formation of secondary dentin on the wall of the pulp chamber opposite the point of irritation. In carious cavities the dentin is usually most sensitive at the junction of the enamel and dentin, while the layer of dentin immediately beneath the carious mass is more sensitive than that beyond it. In some cases even large cavities may be excavated with almost no pain, whereas in others of apparently similar character the slightest touch of the instrument will cause almost unbearable pain. So-called hard or dense teeth are less sensitive than others, owing to the lesser amount of protoplasmic matter in the tubuli.

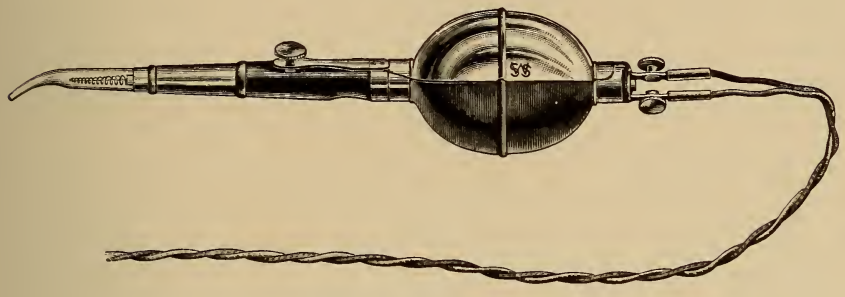
TREATMENT

Remedies may be arranged in two classes. In the first are those that benumb or anesthetize the fibrillæ in the tubuli, and in the second, those that chemically destroy the fibrillæ to a certain depth.

Remedies that Benumb.—Dehydration.—As moisture is necessary to enable nerve filaments to convey sensation to the nerve centres, absence of moisture will necessarily interfere with or prevent such transmission; therefore the simplest and most logical method of producing analgesia, in whole or in part, in a tooth cavity for the purpose of excavating, is to dispel the moisture from the walls of the cavity and from the tubuli which form such surfaces. It has been found that desiccation of a cavity either by ordinary exposure to the air for a length of time, or by subjecting it to a current of warm air will bring about a condition of immunity to sensation in proportion as such desiccation is thorough or partial. To best accomplish desiccation of the dentin, the rubber dam should be adjusted to the teeth and the greater portion of the carious mass carefully removed with spoon excavators; the cavity should be bathed with absolute alcohol, and then subjected to a stream of warm air applied in some convenient manner. The ordinary air syringe or chip blower may have its point heated in a flame, and then by forcing the air in the bulb slowly through the tube, a jet of warm air will be delivered in the cavity. By holding the nozzle of the syringe at the proper distance, and having learned by experience how much heat to apply, one can often inject a current of air into the cavity at nearly the same temperature as that of the tooth; but if the air, when it reaches the cavity, should be either perceptibly above or below the proper temperature, pain will be produced. In some warm-air syringes the tube is provided with a hollow receptacle somewhere along its length, which, when heated, raises the temperature of the air within it before being directed into the tooth cavity. Neither of these methods is at all exact, and they are therefore liable to produce more or less pain in the act of dehydration. A better plan is to employ a syringe in which a coil of fine platinum wire is

contained within the orifice; this coil is connected by wires through the body of the syringe with a source of electric current; in operation the resistance encountered by the current of electricity passing through the platinum coil heats it and maintains a steady temperature. Air forced over this coil and through the nozzle, especially air supplied from a receiver and under pressure that can be controlled, may be heated to a temperature that will approximate very closely that of the tooth, and therefore produce little or no pain. If the air passing from the nozzle of the syringe should be too warm, it can be modified by holding it a little farther away from the tooth, or if not warm enough, more heat will be delivered when it is held in closer proximity.

Fig. 108



Electric warm-air syringe.

Fig. 108 represents an instrument of this character with a compressible bulb instead of an air supply from a receiver. The operation of desiccation should not be hurried; time must be allowed for raising the air to a suitable temperature, so as to cause as little pain as possible. In addition, the operation should be continued until the dentinal walls of the cavity have become perceptibly lighter in color, indicating that they have been robbed of their moisture. If desiccation is not carried to this point it will fail in its effectiveness; but if the moisture has been removed from the dentin to a considerable depth, as it may be if desiccation be sufficiently continued, sensitiveness will have become nearly or entirely obliterated. Whether we depend entirely upon dryness to relieve the hypersensitivity or not, it should always be resorted to, for it proves a most valuable preliminary where it is to be followed by medication of any kind.

Another means of avoiding excessive pain in excavating is by the use of sharp instruments and burs. It is well known that a sharp instrument will sever sensitive tissue with less pain than a dull one, and this is equally true in the cutting of a substance like dentin, which contains a considerable amount of organic matter. Burs cause pain in operating principally through dulness or through being held in contact with the cavity wall too continuously. They should not only be sharp, but run at high

speed and allowed to touch the surface very lightly as they revolve; this avoids the heat of friction and consequently lessens pain.

Topical Medication.—Refrigeration by a spray of ether or ethyl chlorid will reduce the temperature of the sensitive tissue and benumb it, but this is a painful method and consequently not often resorted to. A constant stream of warm water slightly above the temperature of the blood, directed into the cavity during the operation of excavation has been found in many cases greatly to lessen the normal sensitivity of the part; but as it is inconvenient to use and very difficult for one to operate in the presence of this stream of liquid, the method has not been generally adopted. Vapocain, a proprietary remedy consisting of a 15 per cent. solution of cocain in ether, found some favor a few years ago for reducing the hypersensitiveness of dentin previous to excavating, but as it was not efficient in a large number of cases it soon fell into disfavor. Cocain hydrochlorid in a 10 per cent. to 25 per cent. aqueous solution forced into the tubules sometimes produces a mollifying effect, but it is difficult to retain the liquid and apply pressure except in cavities of limited size and favorable form.

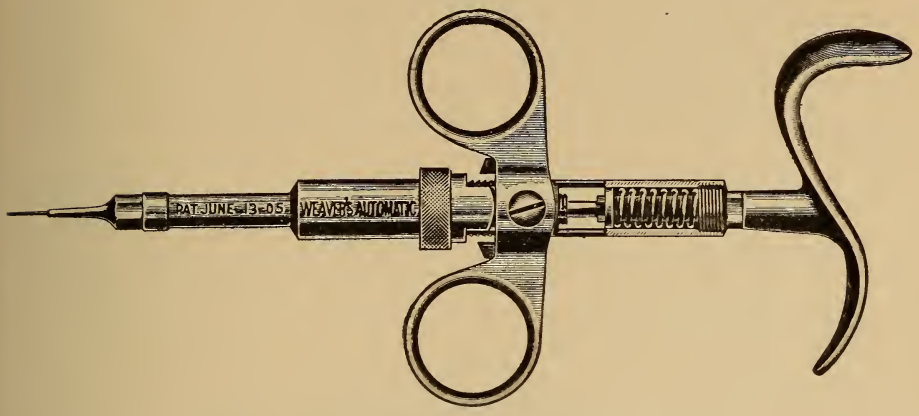
The late Prof. W. D. Miller claimed good results from the following method: After removing the bulk of debris from a cavity, he packed a mass of vulcanizable rubber into it to take its form. Removing this and drying the cavity he placed within it a small portion of cotton, saturated with a 10 per cent. solution of cocain hydrochlorid. Replacing the mass of rubber in the cavity, he exerted pressure upon it in such manner as to force the solution into the tubuli and produce desensitization. By repeating the treatment at intervals during excavation, he was able to prepare very sensitive cavities with very little pain.

Electrical Osmosis.—Another method of employing cocain is by having it carried into the substance of the dentin by means of electrical osmosis. This process, known as cataphoresis, consists in placing a solution of cocain on cotton in the sensitive cavity, and having it carried along the dentinal tubuli toward the pulp by means of a galvanic current. A battery is employed with the negative electrode inserted in the cavity, and the anode placed upon some part of the patient's body, as the hand or cheek. The current carries the cocain into the deeper portions of the tooth and anesthetizes it. While in this condition, which usually lasts for an hour or more, the tooth may be worked upon without any pain. For a while this method met with great favor because of the perfect results obtained, but later it was found to be a very slow method, often consuming more time than the operator had at his command, and occasionally requiring a second application in order to produce complete anesthesia of the tooth; in addition, the cocain in some cases penetrated to the pulp itself and devitalization followed.

Cocain Analgesia.—A better method of using cocain for anesthetization consists in forcing a weak solution of it into the dentin of a tooth

by means of a powerful compound pressure syringe. Several instruments of this character are on the market, but that known as the Weaver is probably one of the most efficient. It is shown in Fig. 109.

Fig. 109



In use a small pit is drilled through the enamel to the dentin with a No. ½ bur, the nozzle of the syringe being tapered to fit the pit accurately. After the barrel of the syringe has been charged with a 5 to 15 per cent. solution of cocain in water, the point is forced tightly into the pit in the tooth, and pressure brought to bear upon the plunger of the syringe. If the fit between the drill-pit and the nozzle point is accurate, and the pressure in the syringe is kept up for one or two minutes, it will be found that the dentin has become entirely anesthetized and can be operated upon without pain. As this method is much simpler than that of cataphoresis, it has met with great favor. Some practitioners have hesitated to adopt the use of the syringe for fear of the anesthetization being carried so far as to result in pulp devitalization. There is, of course, this possibility if the pressure be continued too long, and also in cases where the resistance of the teeth to such pressure is less than normal, but those who have adopted the method and have become familiar through experience with the conditions that favor its employment are very loud in its praise. This method of injecting cocain is also frequently employed to desensitize dentin in the gradual approach to the pulp for its devitalization. Secondary dentin is difficult to penetrate on account of its greater density; sometimes several applications being required before anesthetization is accomplished. Still another method of relieving hypersensitivity of the dentin consists in injecting a 1 per cent. solution of cocain into the gum tissue overlying the apex of the root. This acts by paralyzing the sensory nerve leading from the pulp. Some practitioners claim very satisfactory results from its use.

General Anesthesia.—This radical method of treatment, while very seldom called for, is of the very greatest value in cases where the hypersensitivity of cavities is so extreme as not to permit of the least progress in excavation, and where the nervous condition of the patient does not warrant the infliction of any pain whatsoever. In the inducement of this condition, some of the general anesthetics may be employed; several are serviceable, and the choice rests with the operator. Somnoform, a proprietary compound, consisting of ethyl- and methyl-chlorid and ethyl-bromid, has won favor in dental and surgical practice, and has been found to be reasonably safe in its anesthetic action. Chloroform has been used on account of its rapid action and the freedom from nausea, but its unfavorable action on the heart in some cases should prohibit its use in dental practice. In the employment of ether only sufficient of the drug should be inhaled to induce partial or peripheral anesthesia. Frequently, while there is absence of sensation, consciousness is still present.

Fig. 110

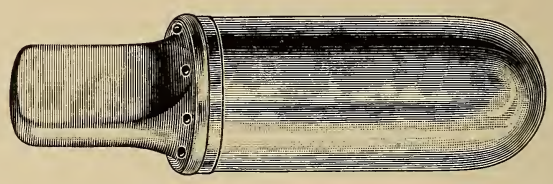


Fig. 110 represents a simple appliance for convenient administration. It is a metal tube about one inch in diameter, with a convex termination at one end having a central opening about three-sixteenths of an inch in diameter. Into the other end is fitted a cap with an extension for holding in the hand. In use, the tube is loosely filled with cotton, upon which a quantity of the anesthetic is poured. After the cap is replaced the appliance is given to the patient with instructions to hold it to the nose and inhale. When the hand drops it is evident that muscular relaxation and partial anesthesia have been produced, and excavation can be proceeded with. When sensation returns the patient will have to repeat the inhaling to again produce anesthesia, when further operations may be resumed. By this mild administration the patient is absolutely relieved of all pain without any unpleasant effects. In this as in all other cases where insensibility is produced the operator must proceed with great caution, otherwise the pulp may be reached and injured without warning. The writer has had several cases in which he could accomplish nothing by the usual methods of desensitization, but which were rendered amenable to treatment by partial general anesthesia. In ordinary practice it will be found that thorough desiccation under the rubber dam with sharp instruments delicately handled, and an occasional application of carbolic acid, will usually

mitigate or relieve most of the pain in nine-tenths of all cases presenting; for the balance, where sensitivity is unusual, the high-pressure syringe and cocain will be found most effective.

Remedies which Chemically Destroy the Fibrils to a Limited Depth, Preventing Transmission of Sensation, are the Common Cauterants.—Those principally used for this purpose are zinc chlorid, silver nitrate, carbolic acid, and the latter combined with potassium hydroxid. To cause coagulation or destruction of the tubular content, their efficiency depends upon the length of time they are applied, and all of them cause more or less pain.

Zinc Chlorid is more irritating than the others, but by adding crystals of cocain to the zinc chlorid at the time of its application this effect may be modified. In deep-seated cavities it should not be employed on account of the danger of pulp irritation either at the time of application or subsequently.

Carbolic Acid.—This drug may be applied in full strength to cavities of any depth without danger. It operates quickly but not to any great depth, and is the most generally used of all obtundents. Whenever used for desensitization the cavities should be dried as thoroughly as possible before application, for in this way the acid is not diluted to so great an extent by the water in the tubuli. Cavities sensitive to air after excavation are immediately relieved by the application of carbolic acid. It not only serves to counteract thermal shock after filling, but gives to the tooth a warm and comfortable feeling. For this reason many operators, as a precautionary measure, wipe all cavities with carbolic acid before filling. Another virtue possessed by carbolic acid is that of a sterilizer of dentin.

Silver Nitrate.—This salt is slow in action and does not operate to a great depth; it cauterizes the contents of the tubuli and gives them a protective coating. It is useful on denuded dentin at the necks of teeth or exposed surfaces on the tooth crown. The discoloration produced by its use is objectionable, but on all exposed dentin surfaces where it is not visible it is an admirable desensitizer.

Robinson's Remedy.—This preparation is composed of equal parts of caustic potash (potassium hydroxid) and carbolic acid; it is sometimes useful in relieving sensitiveness in cavities, though it is generally preferred for application, like silver nitrate, to denuded surfaces, and operates by destroying the tubular contents. Some operators occasionally depend upon time and the presence of a filling to mitigate hypersensitiveness.

Temporary fillings, the various zinc cements or non-conducting gutta-percha, will frequently produce a marked effect in this respect. After partial excavation and filling with some temporary material, it has been found that the tooth becomes less sensitive to thermal influences, and that after the temporary filling has remained in a cavity for several months, excavation may be resumed and carried forward with com-

parative comfort. The change in sensitiveness of a cavity brought about by the presence of a non-conductive filling was formerly attributed to a process of eburnation or solidification of the tubular structure, but more recent investigations indicate that it is due to a deposition of secondary dentin on the walls of the pulp chamber, thus increasing the mass of dentin through which sensation has to be conveyed. Usually, hypersensitive dentin needs to be treated at the time of its discovery during excavation so that the operation may not be needlessly delayed.

CHAPTER VII

TECHNIQUE OF CAVITY PREPARATION

By THOMAS E. WEEKS, D.D.S.

In the light of our present knowledge we must consider all cavities as the result of some pathological condition. We cannot consider a carious tooth as an individual apart from its fellows and its environment, or the cavity simply as a hole to be filled. We must study the mouth and teeth as a whole and endeavor to determine what abnormal or pathological conditions are responsible for the beginning of any particular cavity.

We know that caries is the result of the breeding, growth, and life activities of certain microörganisms, that these microörganisms must be sheltered and protected, else they are destroyed or their action inhibited by nature's weapons against disease which are present in every mouth.

We know that well-formed teeth, arranged in proper relation to their fellows, both as regards *contact* and *occlusion*, in mouths which are maintained in a clean, healthy condition, seldom decay.

Assuming that the student's knowledge of dental anatomy is sufficient to enable him to recognize normal conditions, the following several points should be noted: (1) Form of the teeth; (2) their arrangement in the arch; (3) their proximal contact; (4) the interproximal spaces and embrasures; (5) occlusion; (6) the health of the gums, and especially the condition of that portion which *should* fill the interproximal spaces.

Without a knowledge of what *is* normal we cannot recognize the abnormal. Unless we can determine how much we can improve existing conditions by our completed operation, the preparation of any given cavity will not be performed with that intelligence necessary to insure the best results.

A perfect, well-formed tooth is one in which there are no structural imperfections which result in pits and fissures, having such form that when in position in the arch it will make perfect contact with its fellows (similarly well formed), *i. e.*, a small contact point in the incisal or occlusal third in both labio-lingual and gingivo-occlusal aspects. If this form prevails, the result must be well-formed interproximal spaces,

with sufficient septum of alveolar tissue to support and nourish enough healthy gum tissue to properly fill the space. With such form we will have broad embrasures, which will insure the cleansing of all of that portion of the proximal surfaces not covered and protected by the gum septum in the movement of the food as it is forced rootward in the act of mastication. When we consider the cases on record where all of the teeth have been forced into improper occlusion by the imperfect occlusal form of one filling, the importance of the occlusion is apparent. When we have reached this point in our diagnosis it will usually be apparent that much of the unhealthy condition of the soft tissues, if any exist, is due to some of the faulty conditions in form already noted. When this is corrected and normal spaces restored, the tissues will resume a healthy appearance. If due to other causes, it is usually amenable to treatment detailed in another chapter.

In order that the text may be intelligible we must understand the language of its descriptions. The nomenclature employed is that adopted by the National Institute of Dental Pedagogics, which is based upon the suggestions of Dr. Black, and applies only to prepared cavities:

REPORT OF COMMITTEE NATIONAL ASSOCIATION OF DENTAL PEDAGOGICS.

CAVITY NOMENCLATURE

All that is to be said in describing cavity preparation can be expressed by the use of the following nouns and adjectives:

Cavity,	Surface,	Labial,	Mesial,	Gingival,
Wall,	Angle,	Buccal,	Distal,	Axial,
Margin,	Thirds,	Lingual,	Incisal,	Pulpal,
Plane,	Embrasure,	Proximal,	Occlusal,	Subpulpal.

CAVITY NAMES

Cavities in the teeth take the names of the surfaces in which they occur.

- Cavity
 - Simple
 - Labial,
 - Buccal,
 - Lingual,
 - Mesial,
 - Distal,
 - Occlusal.
 - Complex
 - Mesio-incisal,
 - Disto-incisal,
 - Mesio-labial,
 - Disto-labial,
 - Mesio-lingual,
 - Disto-lingual
 - Mesio-occlusal,
 - Disto-occlusal,
 - Linguo-occlusal,
 - Bucco-occlusal,
 - Mesio-distal-occlusal,
 - (Other combinations by the same rule.)

WALL NAMES

That wall of a cavity in an axial surface of a tooth that covers the pulp is called the *axial* wall. If the cavity is extended to include the pulp chamber this wall takes the name of the wall of the pulp chamber. The bottom or floor of occlusal cavities is called the *pulpal* wall. If extended to include the pulp chamber it becomes the *subpulpal* wall.

WALL { Labial, Buccal, Incisal, Occlusal, Lingual, Mesial, Distal, Gingival, Axial, Pulpal, Subpulpal.

Rule, cavity walls take the names of the surfaces of the tooth which they approach.

ANGLES (SIMPLE CAVITIES)

ANGLES {

LINE (AXIAL) {
- Mesio-buccal, — OCCLUSAL CAVITIES.
- Mesio-lingual, — OCCLUSAL CAVITIES.
- Disto-buccal, — OCCLUSAL CAVITIES.
- Disto-lingual. — OCCLUSAL CAVITIES.
- Bucco-axial, — AXIAL SURFACE CAVITIES.
- Linguo-axial, — AXIAL SURFACE CAVITIES.
- Mesio-axial, — AXIAL SURFACE CAVITIES.
- Disto-axial, — AXIAL SURFACE CAVITIES.

LINE (PULPAL) {
- Bucco-pulpal, — OCCLUSAL CAVITIES.
- Linguo-pulpal, — OCCLUSAL CAVITIES.
- Mesio-pulpal, — OCCLUSAL CAVITIES.
- Disto-pulpal. — OCCLUSAL CAVITIES.
- Bucco-gingival, — AXIAL SURFACE CAVITIES.
- Linguo-gingival, — AXIAL SURFACE CAVITIES.
- Mesio-gingival, — AXIAL SURFACE CAVITIES.
- Disto-gingival, — AXIAL SURFACE CAVITIES.
- Axio-gingival, — AXIAL SURFACE CAVITIES.
- (and combinations with occlusal wall). — AXIAL SURFACE CAVITIES.

POINT . . {
- Mesio-buccal-pulpal, — Mesio-linguo-pulpal,
- Disto-bucco-pulpal. — Disto-lingual-pulpal.

}

POINT ANGLES (the union of three line angles) take their names from the surfaces forming them. In occlusal cavities there are four.

In complex cavities on axial surfaces there is another horizontal line-angle, *i. e.*, in axial cavities combined with occlusal, the one formed by union of the axial and the pulpal wall—*axio-pulpal*.

DIVISION INTO THIRDS

Cavities may be divided into thirds, for convenience in description, as teeth are divided.

NAMES OF MARGINS

MARGINS { Mesial, Distal, Buccal, Labial, Lingual, Incisal, Occlusal, Gingival.

Nomenclature of Simple Cavities

	Occlusal Cavities	Labial, Buccal, or Lingual Cavities
Walls	Mesial, Distal, Buccal, Lingual, Pulpal.	Mesial, Distal, Gingival, Occlusal or Incisal, Axial.
Line Angles (Longitudinal)	Mesio-buccal, Mesio-lingual, Disto-buccal, Disto-lingual.	Mesio-axial, Disto-axial.
Line Angles (Transverse)	Mesio-pulpal, Disto-pulpal, Linguo-pulpal, Bucco-pulpal.	Mesio-occlusal, Disto-occlusal, Mesio-gingival, Disto-gingival, Occluso-axial, Gingivo-axial.
Cavo-surface Angles[1]	Mesio-occlusal, Disto-occlusal, Bucco-occlusal, Linguo-occlusal.	Based on the same rule as for occlusal cavities.
Point Angles	Mesio-bucco-pulpal, Disto-bucco-pulpal, Mesio-linguo-pulpal, Disto-linguo-pulpal.	Mesio-axio-gingival, Disto-axio-gingival, Mesio-axio occlusal, Disto-axio-occlusal,
Margins	Mesial, Distal, Buccal, Lingual.	Mesial, Distal, Gingival, Occlusal or Incisal.

Simple cavities on proximal surfaces have the same number of walls, angles, and margins as those on other axial surfaces, and are named similarly.

With this basis all cavities, however complex, may be easily named and described.

Cavity Classification, Nomenclature, and Preparation

Classification

Cavities	Pit and Fissure. (No extension for prevention)	Cavities in the lingual surfaces of upper incisors. Cavities in occlusal surfaces of bicuspids and molars. Cavities in the occlusal two-thirds of the buccal and lingual surfaces of molars.
	Smooth Surface (Extension for prevention)	Cavities in the gingival third of the labial, buccal, and lingual surfaces. Cavities in proximal surfaces of incisors and cuspids which do not involve the mesial or distal incisal angle. Cavities in proximal surfaces of incisors and cuspids which do involve the mesial or distal incisal angle. Cavities in the proximal surfaces of bicuspids and molars.

Note.—Cavities occurring in consequence of arrested development are not included.

This report was adopted by the Institute.

[1] Cavo-surface angle—An angle formed by a wall of a cavity and the surface of the tooth in which the cavity is situated.

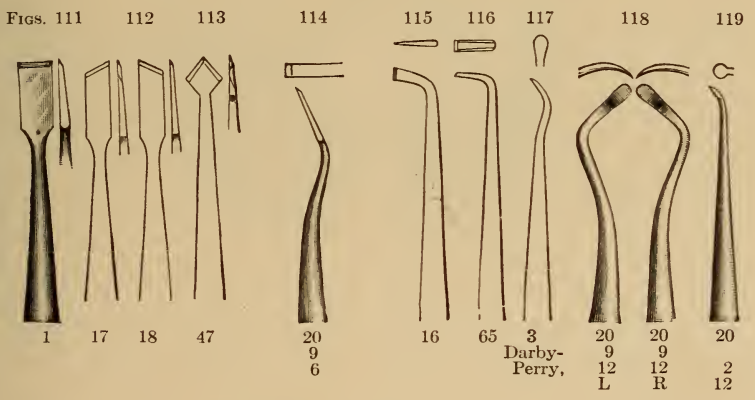
PREPARATION

In cavity preparation there are four definite steps:

1. Establishing outline of the cavity.
2. Removing softened dentin (decay).
3. Giving the cavity proper shape. This includes resistance form, retention form, and convenience form.
4. Bevelling and smoothing the enamel wall.

INSTRUMENTS

The instruments used in cavity preparation are hand instruments—those held in and manipulated by the hand; and engine instruments—those held in a hand-piece and revolved by power. The power instruments or burs have the same advantage over hand instruments that the power planer has over the hand planer, but owing to the peculiar construction of the teeth, especially the enamel, there are many parts of the operation which may be more effectively and speedily performed with

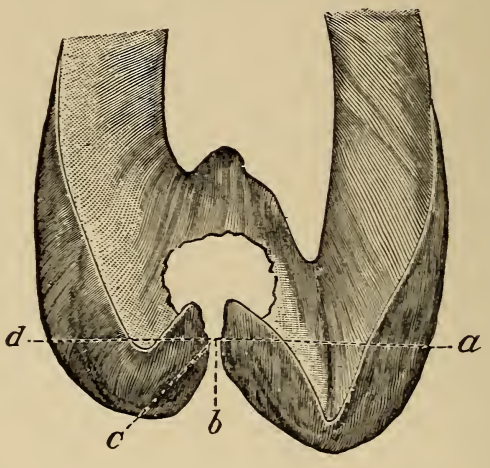


hand instruments. The hand instruments used are chisels and excavators. Chisels are straight (Fig. 111), oblique (Fig. 112) (this form is made in pairs, right and left), or double oblique (Fig. 113), and those in which the blade is at an angle with the axis of the shaft (Fig. 114). Excavators are divided into three classes, according to the form or position of the blade: hatchets, hoes, and spoons, or discoids. Hatchet excavators are those in which the hatchet-shaped blade is at an angle with the axis of the shaft, with its edge in the plane of the angle (Fig. 115). Hoe excavators are those in which the hoe-shaped blade is at an angle with the shaft, with its edge at right angles with the plane of the angle (Fig. 116).

Spoons are either contra-angle hoes, with a rounded cutting edge, for direct cutting, or contra-angle rights and lefts, for side cutting (Figs. 117 and 118).

Discoids have a disk-shaped blade with a cutting edge around the whole periphery except where it is attached to the shank (Fig. 119). As the point to be operated upon is so frequently inaccessible to direct force, the necessity arises for oblique chisels or those which, like excavators, have the blade at an angle with the shaft. If the point to be operated upon can be approached so the force can be delivered in a straight line from the hand or mallet to the point to be cut, the handle, shank, and blade may have a common axis (Fig. 120 *b*). If the point to be operated upon is not accessible to direct force, *i. e.*, when the force

Fig. 120



must be delivered from a point somewhere between *b* and *d* (Fig. 120), we must employ chisels of the oblique type or those with the blade at an angle with the shaft, or excavators. In instruments having angles, the angle between the shaft and blade is greater or less as the point of approach is far from or near to the line *b* (Fig. 120).

Angles and curves between blades and shafts and in shanks are for the purpose of bringing the blade into direct action upon surfaces which are inaccessible to straight instruments.

These angles are expressed in centigrades (Black), divisions of the circle into 100 equal parts; each part is called a centigrade (Fig. 121). If the shaft of an excavator is laid upon a line passing vertically through the centre of the circle, with the angle between the blade and shaft at the centre of the circle, the line which passes through the centre of the blade will indicate the degree of the angle in centigrades (Fig. 122).

Excavators in common use have an angle somewhere between 6 and 28 centigrades. It has also been found that those most universally used

are those having angles 6, 12, and 23. These differences in angles divide all forms of excavators into three groups. The next point of difference between excavators is the variation in width and length of blades. The width may be expressed in tenths of a millimeter and the length in millimeters. Observation also shows that those most used have blades 0.12, 0.8, and 0.6 mm. wide, and 5, 3, and 2 mm. long.

Fig. 121

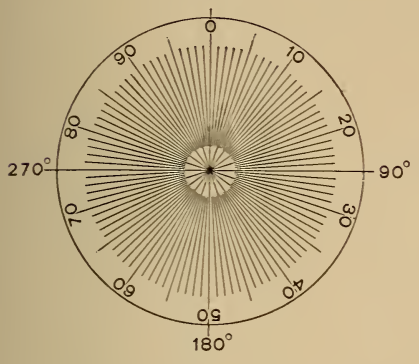
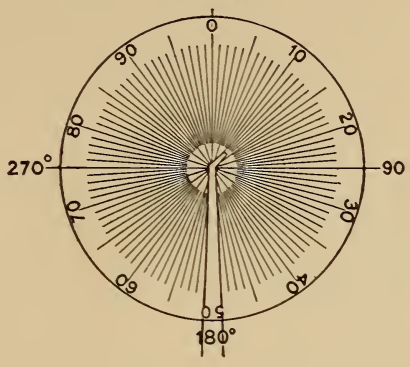


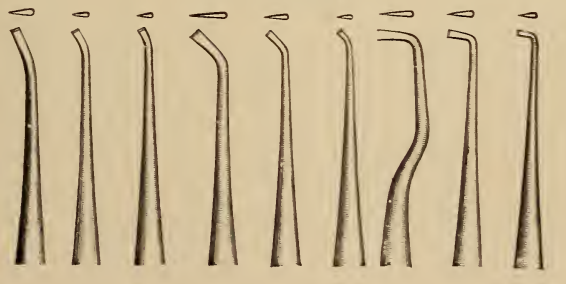
Fig. 122



Understanding these measurements, the dentist can accurately express in figures the width of blade, the length of blade, and the angle between the blade and the shaft so that any instrument maker can make the instrument desired from a formula. In writing a formula, the first figure expresses the width of the blade; the second, the length of the blade; and the third, the angle between the blade and the shaft (deviation from the axis of the shaft in centigrades). Arranging the hatchet and hoe excavators most widely used into three groups, the formulæ appear as follows:

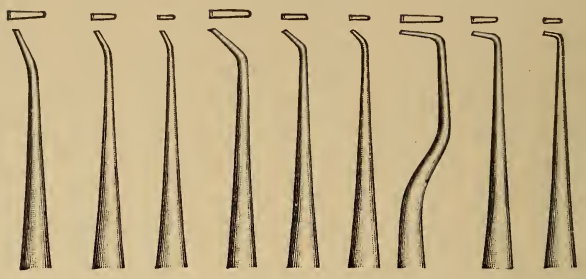
12	8	6	12	8	6	12	8	6,	width of blade.
5	3	2	5	3	2	5	3	2,	length of blade.
6	6	6	12	12	12	23	23	23,	angle in centigrades.

Fig. 123—Hatchets.



12	8	6	12	8	6	12	8	6
5	3	2	5	5	2	5	3	2
6	6	6	12	12	12	23	23	23

Fig. 124—Hoes.

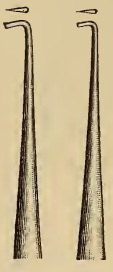


12	8	6	12	8	6	12	8	6
5	3	2	5	3	2	5	3	2
6	6	6	12	12	12	23	23	23

There are two other hatchets which are almost indispensable in shaping the retention angle in the incisal third of proximal cavities in incisors and cuspids; these have an acute angle between the blade and the shaft. Their formula is as follows:

5	3
3	2
28	28—2 instruments.

Fig. 125



5	3
3	2
28	28

When the blade of an excavator is more than 3 mm. long and the angle is 12 centigrades or more, there should be two angles, one contra to the other (contra-angled). The rule for contra-angling is that the angles be so formed that the edge of the blade is in line with the central axis of the shaft, or when the handle is laid on a plane surface the edge of the blade will just touch the surface. In spoon excavators there are two types, the contra-angle spoon, or modified hoe, in three sizes, expressed by the following formulæ:

10	20	30
3	4	5
12	12	12—3 instruments.

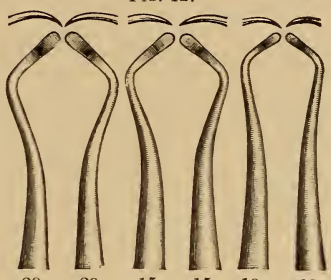
Fig. 126



The other type is the contra-angle double plane, side-cutting rights and lefts:

20 15 10
9 8 6
12 12 12—6 instruments.

Fig. 127

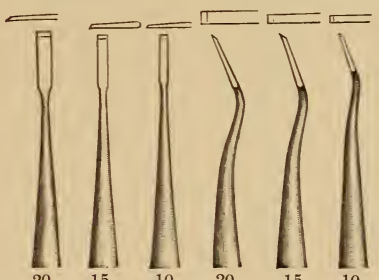


20	20	15	15	10	10
9	9	8	8	6	6
12	12	12	12	12	12
L	R	L	R	L	R

Chisels.—Chisels may be divided into two groups—straight and binangle (contra-angle). Three in each group will be found sufficient. The blades in both groups measure:

20 15 and 10 wide
9 8 and 6 long.—6 instruments.

Fig. 128 Fig. 129



20	15	10	20	15	10
9	8	6	9	8	6
			6	6	6

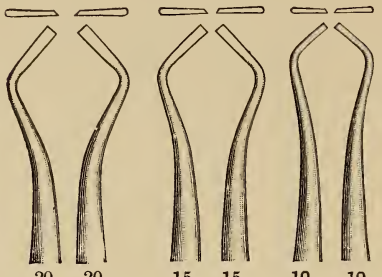
The binangles have an angle of 6 centigrades.

Another form of contra-angle chisels is the enamel hatchet. They are called hatchets because the width of the blade is in the plane of the angles, but they are chisels because the blade is of the chisel form.

They are rights and lefts, and are used as side-cutting instruments. Three pairs will be found useful, the formula for which is as follows:

20 15 10
9 8 6
12 12 12.—6 instruments.

Fig. 130



20 20 15 15 10 10
9 9 8 8 6 6
12 12 12 12 12 12
L R L R L R

Fig. 131

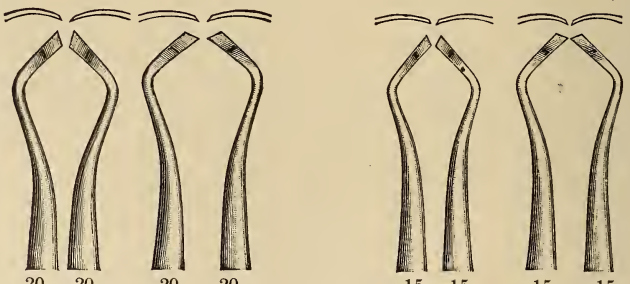


47 48 48 S

Two other forms of chisels which have not been reduced to formula are those known by Catalogue Numbers 47, 48, and 48 S (Fig. 131). Those instruments known as gingival margin trimmers are also chisels. They are contra-angled double plane side-cutting instruments. As the edge of the blade is at an oblique angle with the long axis of the blade, it is necessary to use another figure to designate this. This figure, *which indicates the angle of the edge with the axis of the blade,* is placed between the first and second figures. There are two groups of these instruments formed by the difference in the width of the blades, and the angle between the edge and the axis of the blade. Their formula is as follows:

20 20 15 15, width.
95 80 95 80, angle of edge.
19 9 9 9, lengths.
12 12 18 12, angle.—8 instruments.

Fig. 132



20 20 20 20 15 15 15 15
95 95 80 80 95 95 80 80
9 9 9 9 8 8 8 8
12 12 12 12 12 12 12 12
L R L R L R L R

These instruments are used in giving the final bevel to the gingival, buccal, and lingual walls of proximal cavities, especially in bicuspids and molars.

Fig. 133



Burs.—Burs are divided into two groups, indicated by the manner in which the blades are cut.

Cavity Burs: Those having smooth leaves.

Dentate Burs: Those having the leaves cross-cut or serrated (forming teeth) (Fig. 133).

The first class or group (cavity bur) is divided into eight groups, indicated by the form of the point or head, as follows: Round or rose; oval; pear-shaped; bud-shaped; inverted cone; wheel; fissure (square end); fissure (pointed) (Figs. 134 to 141).

Second class or group (dentate burs) is divided into four groups: Round; pear-shaped; fissure, square end; fissure, pointed. There is still another form of dentate bur, the tapered fissure (Fig. 142). Both square end and pointed. All forms of burs are made in from six to eight sizes, varying from 0.4 mm. to 0.30 mm. in diameter. The sizes mostly used, however, are 0.4, 0.6, 0.8, 0.10, and

Fig. 134 Fig. 135 Fig. 136 Fig. 137 Fig. 138 Fig. 139 Fig. 140 Fig. 141



0.12 mm. in diameter. Burs are catalogued by number, but it is apparent that more accuracy would be attained if manufacturers would designate and dentists would order, by the diameter of the head, indicated in tenths of a millimeter. This is simple if one possesses a Boley micromillimeter gauge (Fig. 143). This instrument is so useful for many other purposes that every dentist should possess one. Dentate burs are designed for cutting enamel. They are made in four forms, as follows: Round; pear-shaped; fissure, square end; and fissure, pointed. They are made in six sizes, but the writer finds that the pear and the fissure, both square end and

pointed, in two sizes, are the most useful (Fig. 144). There are some places, however, where the tapered fissure is very effective (Fig. 142). Cavity burs are designed for cutting dentin, and are made in eight forms, with from eight to twelve sizes in each form. Here again the writer

Fig. 142

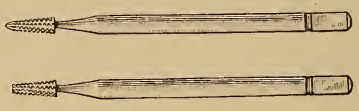


Fig. 143



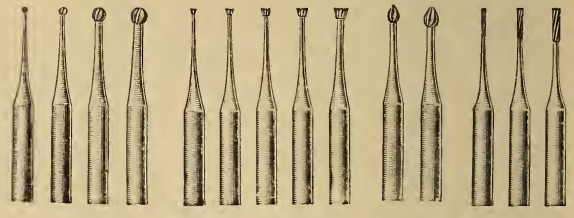
Boley's micromillimeter gauge.

Fig. 144



580 581 568 569 557 558

Fig. 145



½ 2 6 8 33½ 34 35 36 38 49 51 56 57 85

Fig. 146



selects four forms, as follows: 4 round, 5 inverted cone, 2 bud, and 3 square-end fissures (Fig. 145).

Disks, Wheels, and Points.—These are sold under the trade names of Carborundum and Gem. Also small metal disks charged with Carbo-

rundum or diamond dust. Disks are effective in opening fissures. Small wheels and points are very useful in extending enamel walls and shaping cavities for inlays. The most useful forms are shown in Fig. 146. All of these instruments must be kept wet while in use. The selection and manner of using instruments will be treated more fully in the text of cavity preparation.

FIG. 147



In Nos. 1, 3, 4, 5, and 7 are shown typical cavities which occur on the lingual surfaces of the upper incisors and cuspids. When prepared as in Nos. 2, 6, and 8 the outline is established to include all *sulcate* grooves, the cavity in the dentin, which has been given the mortise form, and the enamel walls bevelled sufficiently to give strength to the cavo-surface angle.

The writer believes that the student should be taught in his technique course how, when, and where to use the bur; he will thus appreciate the uses and relative value of both hand and engine instruments and will not attempt enamel cutting and other unwise uses of the engine when he comes to operate on the patient.

PREPARATION OF CAVITIES BY CLASSES

First Step.—*Pit and Fissure Cavities.*—These occur on the lingual surfaces of upper incisors and cuspids. The lingual surface of upper molars, the buccal surfaces of lower molars, but most frequently on the occlusal surfaces of all the bicuspids and molars (Figs. 147, 148, 149, 150, and 151). As these cavities are usually confined to the surfaces upon which they begin, they may be considered as inlays, as this term is applied in mechanics; their outline varying as influenced by the form and markings of the surface upon which they occur.

FIG. 148

1 2 3



The lingual surfaces of the upper molars, especially the first molar, frequently show cavities, as in Nos. 1 and 2. The preparation, as in No. 3, follows the same rules as those given in Fig. 147.

In carpentry, the general form of the cavity for an inlay is the simple mortise (No. 1, Fig. 152). Several forms of its application to teeth are shown in Nos. 2, 3, and 4, Fig. 152. In many locations, because of the direction of the enamel rods, this simple form might result in leaving some enamel rods at the margin of the cavity unsupported by dentin. Fig. 153 (modified from Noyes) shows how this might occur. This condition is overcome by laying that portion of the wall formed by the enamel in a different plane from that formed by the dentin (Fig. 154). Fig. 155 shows a similar cavity, in which the dentin and enamel walls are in the same plane. A careful study of the sections shown will establish

FIG. 149

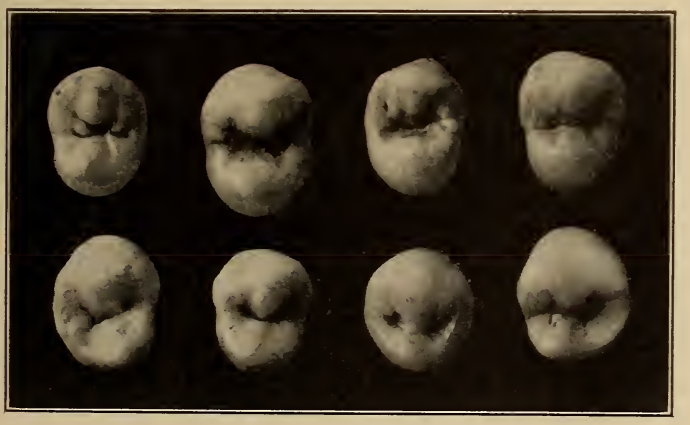
1 2 3



In the lower molars, especially the first molar, cavities occur in the buccal grooves, Nos. 1 and 2. In No. 3 is shown the preparation when the cavity is confined to the terminal fossa. In cavities like Nos. 1 and 2 it would be necessary to extend the cavity to the occlusal surface, connecting it with the occlusal filling, if one be present.

FIG. 150

1 2 3 4



5 6 7 8

The teeth from which these pictures were made, as well as all of those having cavities, that appear in the other plates, were selected from a large number of teeth similarly decayed, as being typical of their class. If lines are drawn to include all *sulcate* grooves and give a graceful outline, the size and form of the prepared cavity will be indicated. (See Fig. 162.)

FIG. 151

1 2 3 4

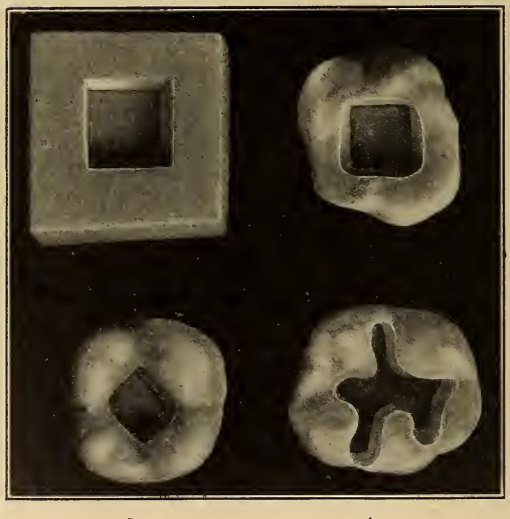


5 6 7 8

These pictures will repay careful study. They are not extremes, only types. Draw outlines to include all *sulcate* grooves, and at the same time preserve all the cusp formation possible. (See Fig. 162.)

FIG. 152

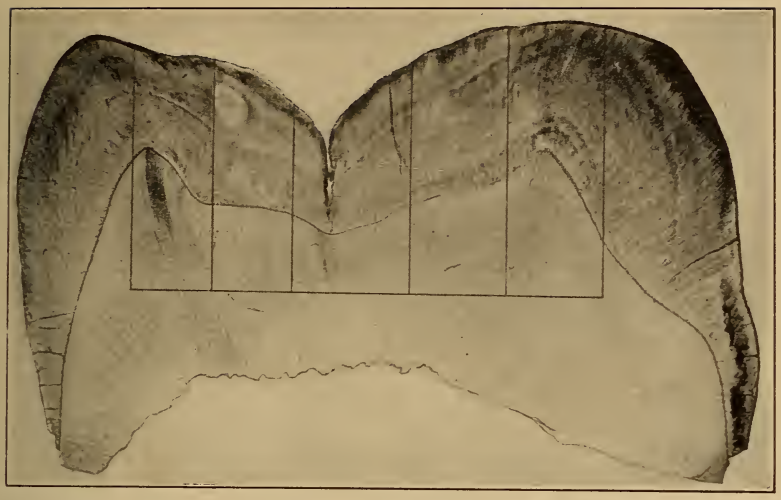
1 2



3 4

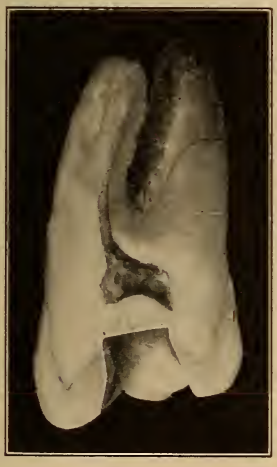
No. 1 shows the simplest form of mortise employed in mechanics. No. 2 is presented, not to show a practical cavity, but to bring out the modification necessary to establish the proper "bevel" of the enamel wall. No. 3 shows a common type of the simple mortise as applied in a lower second molar. No. 4 illustrates the modification necessary to include all susceptible areas. It is still a simple mortise.

Fig. 153



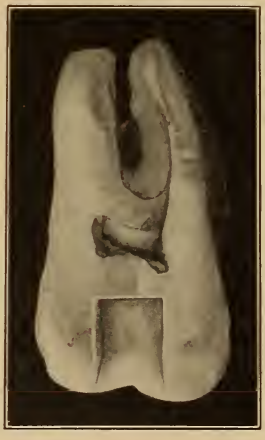
This excellent section, reproduced from a photograph in the writer's possession (by Dr. F. B. Noyes), shows the condition of the enamel rods if cavity walls were laid at any point parallel with the vertical lines. A study of this picture will indicate the line of bevel necessary to protect the enamel rods at any point between the sulcus and the summit of the cusps.

Fig. 154



This section shows the simple mortise form of cavity in the *dentin* with the *enamel* walls properly bevelled to protect the enamel rods.

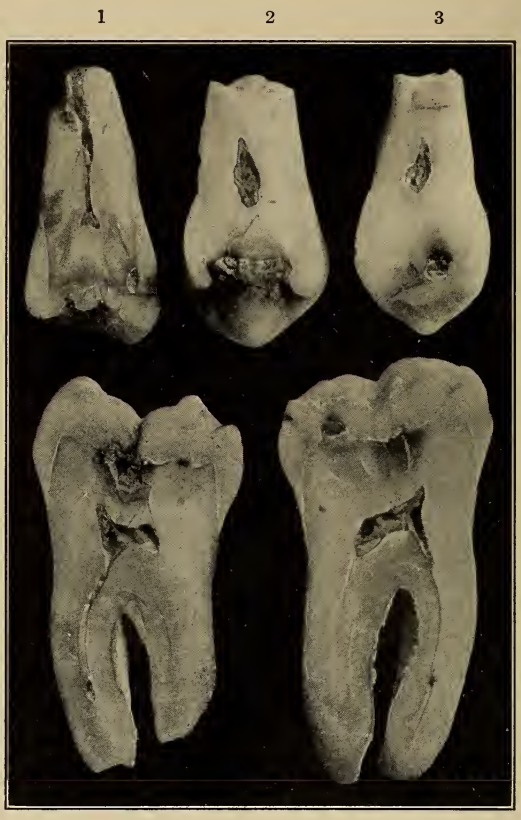
Fig. 155



This section shows a cavity where the dentin walls and the enamel walls are in the same plane. This form of mortise is permissible where the walls are so located that the enamel rods will be protected when the enamel walls are in the vertical plane. This, or some slight modification, is necessary when amalgam is used.

the fact that in the preparation of all cavities we have to deal with two distinct substances, dentin and enamel, and that it is in the dentin that we secure the seat or anchorage for the filling. Also, that the structure of the enamel makes it necessary that it should be so cut that the rods at the cavo-surface angle will rest upon sound dentin. If we divide the walls of a cavity into two parts and think of that portion in the dentin as "dentin wall" and that part in the enamel as "enamel wall" it will simplify our procedure.

FIG. 156



These sections were made from teeth in which the surface indications were no greater than in the smallest cavities shown in Figs. 150 and 151. They illustrate the behavior of caries after the enamel has been penetrated.

In No. 2, Fig. 152, is shown the application of the simple mortise to a cavity in a lower second molar. Sections of similar teeth show how the direction of the enamel rods modifies the simple mortise (Figs. 156 and 157). Following the prescribed order of procedure, we first open the cavity and establish its outline. In those cavities where caries has not progressed so far as to leave the enamel unsupported, it is best to open and extend the fissures with dentate burs, either pear-shaped or pointed

FIG. 157



These sections are from some of the teeth shown in Fig. 151, and are offered as instructive examples of the interior spreading of caries. Note the cutting necessary to establish strong enamel walls in some of them.

FIG. 158



This cut shows a worn fissure bur which has been converted into an effective drill for extending fissures, by bi-bevelling the point.

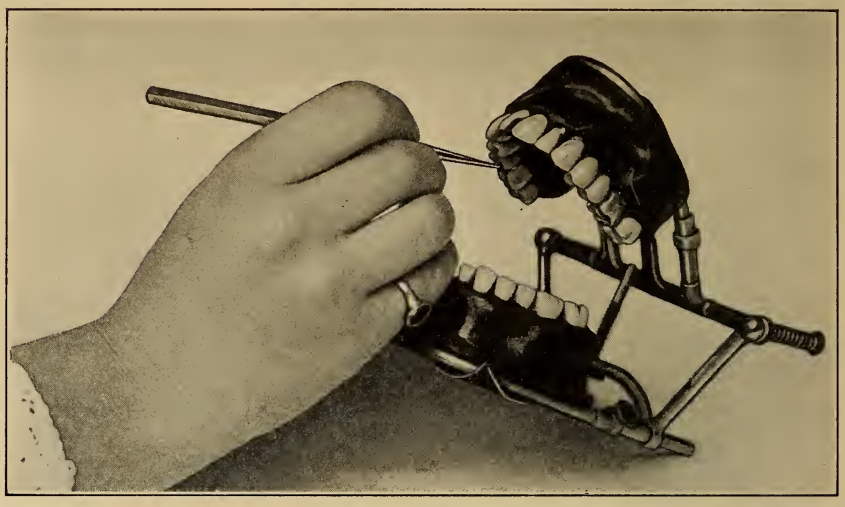
FIG. 159



This cut shows the manner of using a drill made from a worn fissure bur, in opening and extending fissures.

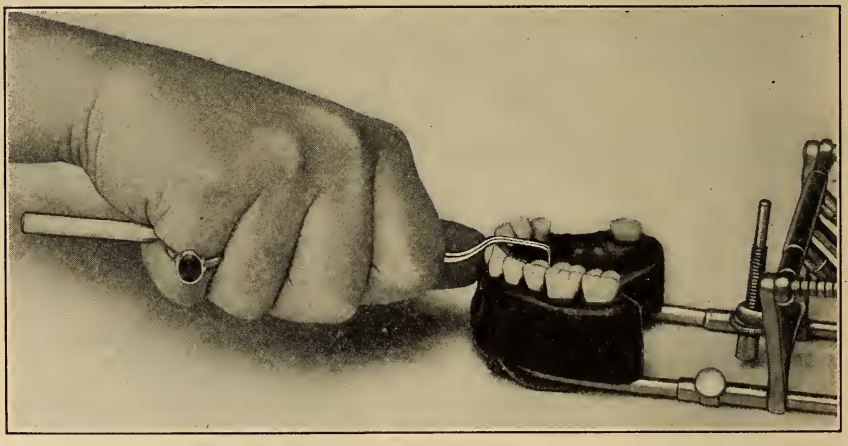
fissure (Fig. 133). Partially worn fissure burs may be made into effective instruments by bi-bevelling the end, forming a drill (Fig. 158). If the bur is entered in a pit to the dento-enamel junction, and the cutting done

FIG. 160



Manner of holding an instrument by the "pen" grasp, and the position of the fingers to provide a "rest."

FIG. 161



Manner of holding an instrument by the "palm" grasp, with the position of the thumb to provide a "rest."

from within outward, it will expedite the work, as enamel cuts much easier in this way (Fig. 159).

After the cavity is opened in this way, or by the extension of the caries, the unsupported enamel is split off with chisels. While these

may be used by hand pressure alone, it is usually best to employ the hand mallet, as much larger pieces may be split off in this way with less discomfort to the patient. In the use of chisels there are two principal grasps—the pen grasp (Fig. 160) and the palm and thumb grasp (Fig. 162). With either of these grasps, rests and guards are necessary. The illustrations will show the manner of using the third and fourth finger in the pen grasp, and the thumb in the palm grasp. The rule for cavity outline in these pit and fissure cavities is that all pits must be extended until the enamel rods at the margin of the cavity rest upon sound dentin and no sulcate grooves radiate from the cavity margin. All fissures must be extended until they become grooves. A study of Figs. 148, 149, 150, and 151 will show the amount of extension which is necessary.

FIG. 162



These figures illustrate a safe preparation of some of the cavities shown in previous plates, and show the application of the simple mortise.

Here let us recall the definition of certain terms (from Black):

Fossa (plural Fossæ): A rounded or angular depression in the surface of a tooth.

Pit: A sharp-pointed depression in the enamel.

Groove: A long-shaped depression in the surface of a tooth.

Sulcus (plural Sulci): A notably long-shaped depression in the surface of a tooth, the inclines of which meet at an angle. A sulcus has a developmental groove at the junction of its inclines.

Fissure: A fault in the surface of a tooth caused by the imperfect joining of the enamel of the different lobes.

In such cavities as occur from faulty union of the enamel along developmental lines in what would normally be fossæ and grooves, it is only necessary that the walls be extended until all enamel unsupported by dentin is removed and until the margins are unbroken by sulcate grooves leading off from them, which would prevent the perfect finishing of the margins of the filling.

These rules have been observed in the preparation of the cavities for the illustrations (Figs. 152 and 162).

Second Step.—*Removal of Softened Dentin.*—After the cavity is opened all softened dentin should be removed with spoon or discoid excavators (Figs. 117, 118, 119). These are usually held by the pen grasp (Fig. 160). The first cutting is made with a sweeping motion, first to the right and then to the left, around the cavity, just below the dento-enamel junction; the deeper portions can then be removed with a lifting motion of the blade. When we begin to operate upon the dentin the whole picture of its structure should rise before us, especially the intimate relation of its organic portion, the fibrillæ, with the pulp and the possible change in its structure as the result of caries. (See Chapter II.) When a cavity presents, the first thing is to ascertain its extent, how much dentin is already destroyed. To do this we must perform the first two steps. Then and only then can we determine intelligently what the outline of the cavity must be. When we discover that in a majority of cases this can be done with chisels and excavators alone, better and easier for the patient, than with the engine, we shall have gained much in the esteem of the patient and in ability as an operator. Figs. 163, 164, and 165 show occlusal cavities with outline established and decay removed.

Third Step.—*Shaping the Cavity for Resistance, Retention, and Convenience.*—When the form of the cavity is established as indicated by the extent of the caries and the cutting necessary to remove faults in the enamel and insure perfect margins in the completed filling, it remains for us to determine how much this form must be changed to meet the above requirements.

When the first two steps have been carefully and thoroughly performed, many cavities need but little modification to provide the necessary resistance, retention, and a form convenient for the insertion of a filling (Figs. 163, 164, and 165, and No. 1, Fig. 166). All cavities of this type may be considered as simple inlays, the fault or hole to be stopped with a mass formed to fit the prepared cavity and inserted *en masse.* Having mastered these principles, it becomes easy to modify forms to meet the demands of the various materials and methods employed. Remember, that now we are considering only simple cavities, those confined to one surface, and having continuous surrounding walls. In

No. 4, Fig. 152, we see the form the mechanic would make, the depth of his cavity varying to meet the demands determined by the nature of the material employed and the amount of stress to which the completed operation is to be subjected. This is what governs *us* in the amount of resistance and retention form we give to *our* cavities.

Fig. 163



Fig. 164



Fig. 165



These sections show the form of cavities after the unsupported enamel has been broken down and the *softened* dentin removed. This comprises the first two steps in cavity preparation.

Referring again to the occlusal cavities in bicuspids and molars, we find that all the stress save that exerted by such adhesive substances as sticky candy, etc., which occur in the food, falls within a radius of 180 degrees (Fig. 120).

Reference to sections of the teeth, appearing in the illustrations, shows that the position of the pulp regulates the depth of the cavity which it is

safe to establish in vital teeth. A rule has been promulgated that the depth of a cavity having parallel walls, should be equal to its diameter (No. 2, Fig. 166, and No. 2, Fig. 167). When this is not possible, we may

FIG. 166



1 2 3

No. 1 shows an occlusal cavity in a bicuspid after the enamel walls have been sufficiently extended and all *softened* dentin removed. No. 2 shows the depth of cavity, as compared with the diameter, necessary to provide sufficient retention when the walls of the cavity are parallel in both dentin and enamel. No. 3 shows the dovetail form in the dentin to provide additional retention, with the enamel walls in a distinctly different plane, to insure protection to the enamel rods.

FIG. 167



1 2

No. 1 shows the enamel bevel which is necessary when gold is the material used for the filling. No. 2 shows an amalgam filling. This cavity has the enamel walls in the same plane with the dentin walls in order that the margins of the filling may be protected from fracture.

resort to the dovetail form (No. 3, Fig. 166, and No. 1, Fig. 167). Referring again to the sections, it will be seen that in the majority of cavities the enamel walls must be divergent, *i. e.*, in a different plane from the

dentin walls; consequently, the retentive form of the cavity is confined to the dentin.

In mechanics, when the simple mortise is insufficient to furnish the necessary resistance, the dovetail mortise is employed. Where the filling is inserted in a plastic form or built in piecemeal, as with gold or tin, this form is easily filled; but when the filling is inserted *en masse*, as in an inlay, the dovetail form must be made after the inlay is fitted, and the cementing substance depended upon to key the piece against stress, if necessary. In most cases where decay has not destroyed sufficient dentin to allow a proper depth to permit parallel walls (where diameter is greater than depth), it is necessary to employ the dovetail form, *i. e.*, to make the dental walls convergent as they rise from the pulpal wall or floor of the cavity (No. 3, Fig. 166, and No. 1, Fig. 167). It is not always necessary that the dovetail form be given to all of the walls. It is often sufficient to apply it to only two opposite walls.

Instrumentation.—As the box or mortise form results in definite angles at the junction of the peripheral walls with the pulpal or axial wall, it is necessary to employ instruments the edge of which is at right or acute angles with the axis of the blade; such instruments are the hatchet and hoe excavators (Figs. 123 and 124). In burs, the inverted cone and the square end fissure are indicated.

In using burs in dentin in vital teeth it will be found much less painful and quite as effective to use the small sizes. In establishing the proper form it is best to get the shape roughly with burs, smoothing the walls and defining the angles with excavators.

If the "convenience points" recommended by Black are indicated, they are best formed with small inverted cone burs (Fig. 145).

Bevelling and Finishing Enamel Walls.—The bevel or plane of the enamel walls is indicated, first, by the direction of the enamel rods at the border or margin of the cavity; second, by the character of the filling material. Observation of the line of cleavage as the enamel splits, when using the chisel, will indicate the bevel or inclination of the enamel wall necessary to insure that the rods at the cavo-surface angle rest upon dentin and that they are supported by a buttress of shorter rods which are covered and protected by the filling or inlay. (See sections shown in illustrations.) In inlays or fillings of gold, which possess ductility, tenacity, and edge strength, the margins of the filling may show more acute angles in section without danger (No. 1, Fig. 167). When porcelain, tin, amalgam, or cement is used, it is necessary to modify the inclination or bevel, that the angle shown in section may be sufficiently strong to avoid the danger of fracture or chipping of the filling under stress (No. 2, Fig. 167). These conditions may make it necessary to extend the enamel walls at certain points beyond the lines indicated by the rules for establishing outlines, already noted.

Whatever the inclination of enamel walls, they should always show a

true plane at any point in section. (See prepared cavities in section.) A short supplemental bevel of the occlusal fifth of the wall (cavo-surface angle) may be given to insure the buttressing already referred to.

Instrumentation.—The final shaping and finishing of enamel walls is best accomplished with chisels and gingival margin trimmers. These must be razor sharp. Fine grinding stones and disks may be used, but the danger is always present of destroying the plane surface—definitiveness of the cavo-surface angle—leaving the wall rounded as in No. 1, Fig. 166. This must be avoided, because it is impossible to properly finish the margins of a filling under these conditions. The most useful forms of chisels are those shown in Figs. 129, 130, 131, and 132.

Final Touches to the Cavity.—As freshly cut surfaces are clean, it follows that the final cutting of all walls should be done after the application of the rubber dam or some other equally efficient means of excluding the fluids of the mouth. When the instrumentation is complete, all surfaces should be carefully wiped with cotton, spunk, or bibulous paper. The practice of flooding the cavity with drugs for their supposed antiseptic value is unnecessary if the cavity is properly prepared—all *decayed* dentin removed. If asepsis cannot be secured by instrumentation alone, the cavity should be sterilized before the final preparation of the enamel walls. When the cavity is to receive an inlay, the walls should be protected in the interim between the preparation of the cavity and the cementing of the inlay, by a temporary stopping and finally washed with alcohol or ether. A safe rule is never to permit the contact of the fluids of the mouth or any viscid or oily substance after the final preparation.

SMOOTH SURFACE CAVITIES

Cavities in the Gingival Third of Labial, Buccal, and Lingual Surfaces of the Teeth.—As these cavities are confined to one surface, they have continuous surrounding walls, and come under the class of simple inlays; consequently, the rules for dentin form and enamel bevels are the same as in pit and fissure cavities. The cause for the occurrence of these cavities cannot be discussed here, but should be considered in establishing the outlines of the cavity. The extent of each cavity must be governed by the conditions existing in that particular case. Reference to Fig. 168 will show that these cavities are not always confined to the gingival third. Even so, they may be distinguished from those cavities which have their beginning in pits and fissures, as this fact influences their outline (Figs. 147 and 148). The preparation of these cavities is shown in Nos. 3, 4, and 5, Fig. 168.

Cavities in the Proximal Surfaces of Incisors and Cuspids Which do Not Involve the Incisal Angle.—These are shown in Figs. 169 and 170. These cavities should have their margins extended until they are so placed as

to be easily cleansed. Specimens are shown in Figs. 171 and 172. When the cavity is opened it will present an appearance like Fig. 173. In com-

FIG. 168

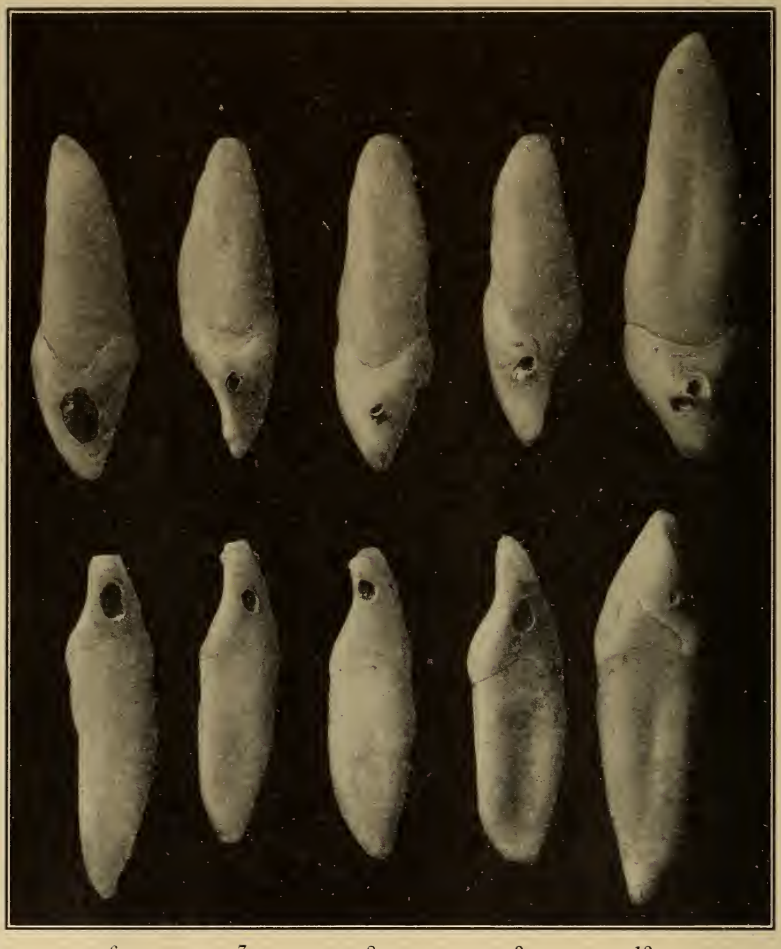


Nos. 1 and 2 show the characteristic cavities which occur in the gingival third of the labial surfaces of the teeth. Nos. 3 and 4 show the preparation of this class of cavities which will insure the best results mechanically and artistically. The lower group (Nos. 6, 7, and 8) offers a study of typical cavities which occur on the *smooth* portion of buccal surfaces, usually in the gingival third. In No. 5 may be seen a typical cavity preparation for this class of cavities.

pleting the cavity form, the gingival wall is made flat in both horizontal planes, with the axial wall meeting it at a right angle. The labial and lingual walls meet the gingival at an acute angle. They also meet the

axial wall at a slightly acute angle in the gingival third. This forms two acute point angles and gives retentive form in the base, or gingival third.

FIG. 169



No. 1 shows a gold filling in which recurrent decay has begun at the labio-gingival and linguo-gingival angles. No. 2, Fig. 176, shows the cavity after the filling was removed, and No. 1 (same Fig.) is the writer's suggestion for a correct preparation, which should include the area of recurrent decay. Nos. 2 to 10 are offered for study as representing typical proximal cavities.

The incisal anchorage is formed by making the labial and lingual walls meet the axial wall at right angles in the incisal third, but the point angle formed by their union is an acute angle with the axial wall. This gives the third leg of the triangular anchorage, which is well shown in Fig. 174 and in No. 4, Fig. 175. There are no undercuts or angles formed by the union of the labial and lingual with the axial wall in the middle third. No. 1, Fig. 169, shows a gold filling where recurrent caries is

beginning at the labio-gingival and linguo-gingival angles. The original preparation of this cavity is shown in No. 2, Fig. 176. If this cavity had been originally prepared, as in No. 1, Fig. 176, recurrent caries would not have appeared. Fig. 177 shows labial and lingual views of this type of cavities. In establishing the labial margin of these cavities, care

Fig. 170



Fig. 171



Fig. 172



Fig. 170.—This section is from the tooth shown in No. 2, Fig. 60, and is worthy of study.

Fig. 171.—Shows a typical preparation for cavities like those shown in Nos. 1 to 5, Fig. 169.

Fig. 172.—A typical preparation for cavities in the lower incisors and cuspids, like those shown in Nos. 6 to 10, Fig. 169.

Fig. 173



Shows a cavity after the first two steps have been performed (establishing the outline and removing all *softened* dentin).

Fig. 174



Shows a cavity where conditions necessitated a little broader cutting. Observe that, no matter what the *size* of the cavity, the general *form* is the same.

should be taken to avoid the semicircular form so often seen. There is a harmony of lines, as well as a harmony of sound and color, and the form shown in the illustrations is more in harmony with the general outlines of the teeth. The lingual wall should be carried far enough on to the lingual surface to include the linguo-marginal ridge. Experience

FIG. 175



No. 1 shows a tooth in which caries has resulted in sufficient loss of substance to demand *extra* incisal anchorage. No. 2 shows the first stage in preparation, and No. 3 a lingual view of the second stage.[1] No. 4 is a section showing the dovetailed form of two cavities where *all* of the incisal point anchorage is provided in an emphasized point angle, and is entirely *within* the cavity walls.

FIG. 176



No. 2 shows the cavity as originally prepared for the gold filling shown in No. 1, Fig. 169. No. 1 shows the writer's preparation of the same cavity. (It was prepared in the same tooth, there being no recurrent decay *in* the cavity.)

[1] The writer uses this term to indicate the order in which a compound cavity is prepared, and should not be confused with "step." The forming of the *main* cavity is the *first* "stage," and the "step" is formed in the *second* "stage."

has shown that recurrent caries is frequent where the lingual wall is left well within the lingual embrasure.

Fig. 177

1 2



No. 1 shows the labial and No. 2 the lingual outline of average cavities which do not involve the incisal angle. This form is more in harmony with the general outlines of the teeth than the semicircular form so often seen.

Fig. 178



Shows the application of the "dovetailed mortise" to a cavity in a cuspid tooth. This form is applicable in teeth having short, thick crowns.

Fig. 179

2



Cavities in both upper and lower incisors which do not involve any more loss of substance than shown in No. 2 may be prepared as in No. 1, emphasizing the gingival and incisal point angles.

Instrumentation.—If caries has progressed so that the enamel is undermined, the chisel (No. 48 S, Fig. 131) is indicated for establishing cavity outlines. When the enamel is not undermined, a small round bur should be used to cut away the dentin immediately beneath the enamel, after which [illegible] may be cut away with chisels. After removing the

FIG. 180



Nos. 1 and 2 show labial and lingual views of cavities like No. 1, Fig, 175, where the "incisal step" is employed. Nos. 3 and 4 show the lingual "step" in similar cavities in such teeth as are too thin in the incisal third to warrant the employment of the incisal "step."

FIG. 181



The application of the "lingual step" in an extreme case for a gold inlay.

softened dentin with small right and left spoon excavators, the retention form is made with small inverted cone burs, completing the gingival point angles with small hoe excavators and the incisal point angle with a small hatchet angle 28 (Fig. 125).

The final enamel bevel is made with sharp chisels. Sandpaper disks and strips should be avoided because of the danger of *rounding* the enamel walls. In proximal cavities in the cuspids the preparation

FIG. 182



These teeth are reproduced as typical of most cavities where the marginal ridge has not been broken down, and show very clearly how form and contour influence the lateral spreading of caries on the surface of the enamel.

shown in Fig. 178 may be employed. This is an application of the dovetail mortise. In all this class of cavities the outline should be such as to produce the best artistic effect, and also to permit the easy and direct introduction of the filling material with the *least possible* separation.

Cavities in the Proximal Surfaces of Incisors and Cuspids which Involve the Incisal Angle.—In these cavities the outline is indicated by the amount of tooth substance missing after all unsupported enamel and softened dentin has been removed. The retention in the gingival

third is of the same form and shaped with the same instruments as in those cavities where the incisal angle is not involved. When the loss of tooth substance is not greater than that shown in No. 2, Fig. 179, the incisal retention may be made between the enamel plates (No. 1, Fig. 179). When this loss is so great as to require a greater bulk of metal to restore contour than that within the cavity, as in No. 1, Fig. 175, we must secure some other kind of incisal retention. Figs. 175 and 180 show the two forms. The incisal step is employed in teeth which have been

FIG. 183



These molars illustrate the same points as those in Fig. 182.

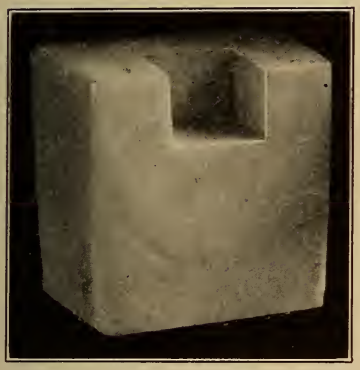
abraded or those that are thick in the incisal third. The lingual step is only used where the teeth are so thin in the incisal third as to preclude the use of the incisal step. In these cavities, as in those of the former class, the retention form is made with inverted cone burs, completing all angles with small hoe excavators, and the enamel margins finished with sharp chisels and trimmers.

In preparing these cavities it is best to complete the preparation of the gingival third before making the incisal or lingual step (No. 2, Fig. 175).

If gold inlays are to be inserted, the same cavity form is made when the incisal step is employed, except that all point angles are less pronounced. If the lingual retention is necessary, the cavity is modified, as in Fig. 181, and the inlay inserted from the lingual surface.

Cavities in Proximal Surfaces of Bicuspids and Molars (Figs. 182 anc 183). —As these cavities always involve the occlusal marginal ridge, except where the adjoining tooth is missing, they come in the class of mortises

Fig. 184



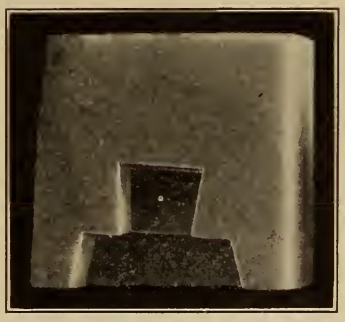
The simple mortise of mechanics where two surfaces are involved.

Fig. 185



The application of the simple "dovetailed mortise" to a molar cavity where the buccal and lingual walls are sufficiently strong to warrant this style of preparation.

Fig. 186



In mechanics, this would be a "compound mortise."

shown in Fig. 184. Where there is no decay on the occlusal surfaces, this simple mortise form may be employed, providing that the buccal and lingual walls are sufficiently strong to retain the filling against the stresses to which it is subjected (Fig. 185). When there is a cavity on the occlusal surface, or where caries has weakened the buccal or lingual wall, the auxiliary mortise or step in the occlusal surface must be made. Fig. 186 illustrates this double mortise, and Figs. 187, 188, and 189

show its application to molar teeth. The preparation of this form of cavity is made by first opening the cavity with chisels (No. 2, Fig. 190).

FIG. 187



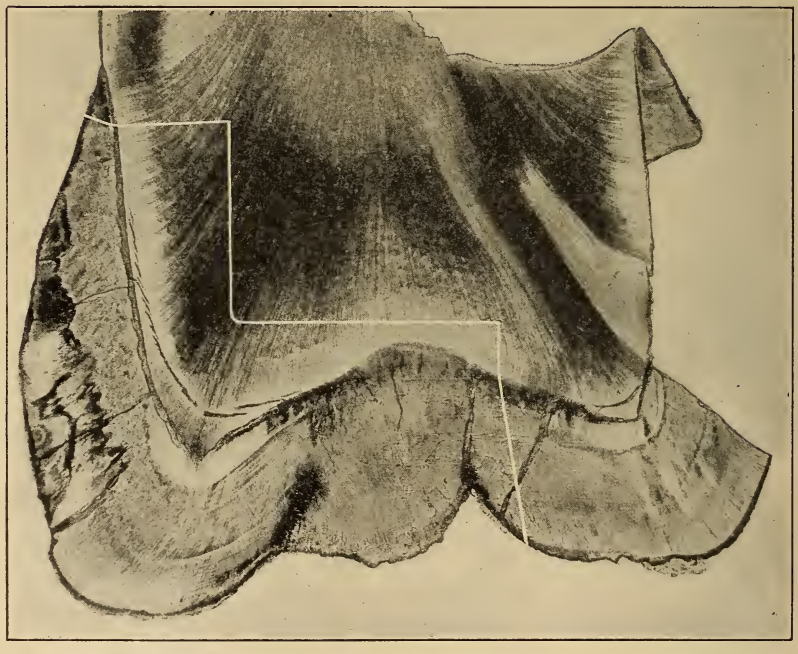
The application of the "compound mortise" or "step" to a molar cavity.

FIG. 188



A proximal view showing the application of the "compound mortise" to a cavity in a molar. Note the supporting dentin between the cusps.

FIG. 189



The line on this section shows the planes and angles in a typical "step" cavity.

The next step after removing the softened dentin is to make the gingival wall flat in both horizontal planes forming the seat. The axial wall

should be parallel with the perpendicular axis of the tooth, which will result in a right angle with the gingival wall (Fig. 189). The buccal and lingual dentin walls should form right angles with the axial wall and the enamel walls bevelled as in Fig. 191. This is done with inverted cone

FIG. 190



No. 1 shows a cavity in a bicuspid No. 2 is a cavity after unsupported enamel has been broken down and all softened dentin removed. No. 3 shows the modification necessary to produce the completed cavity.

FIG. 191



A step cavity in a bicuspid, which shows again how the dentin is preserved to support the cusps.

FIG. 192



FIG. 193



FIG. 194



Several applications of the "step" cavity to molars. In all of these the effort has been made to meet the requirements of a *safe* cavity outline for the enamel with the least sacrifice of dentin in securing retention form.

or square end fissure burs, and chisels for the enamel wall, emphasizing the angles with hoe excavators. The step is formed in the same way and with the same instruments as a simple pit and fissure cavity. The preparation should be such as to permit the insertion of a cast inlay. If a welded gold filling is decided upon, it is only necessary to emphasize

Fig. 195



A section showing the planes and angles in an extensive "step" cavity.

Fig. 196



An occlusal view of the cavities shown in Figs. 188, 192, 193, and 194. These show that the form of the auxiliary cavity or "step" was determined by the sulcate grooves.

Fig. 197



A section of one of the teeth shown in Fig. 182, illustrating the necessity for the liberal cutting seen in some of the previous pictures.

the point angles with inverted cone burs and hoe excavators. If amalgam is to be used, the bevel of the enamel walls must be less, especially on the occlusal surface. The illustrations show the several types of this form (Figs. 192, 193, 194, 195, and 196).

One important point is to retain all the dentin possible between the cusps. (See illustrations.)

CHAPTER VIII

EXCLUSION OF MOISTURE—EJECTION OF THE SALIVA—APPLICATION OF THE DAM IN SIMPLE CASES, AND IN SPECIAL CASES PRESENTING DIFFICULT COMPLICATIONS—NAPKINS AND OTHER METHODS FOR SECURING DRYNESS

By LOUIS JACK, D.D.S.

The interference of the *secretions of the mouth* constitutes an obstacle to the treatment of the teeth. In some instances the flow is naturally excessive, and in all cases it is stimulated by the operative procedures.

An excessive flow of saliva is uncomfortable to the patient; its accumulation also impedes the operation, and interferes with the view of parts by refracting the rays of light.

During the preparation of accessible cavities, particularly those of the upper front teeth and the occlusal surfaces, the accumulation may be carried off by the use of a *saliva ejector*, a simple form of which is shown in Fig. 198, which form, or some modification of it, is used when a connection can be made with the water supply, and ordinarily it is used in association with the fountain cuspidors. Another form, which is connected with a small reservoir of water, is shown in Fig. 199. Either of these forms has a further use for drawing off the saliva in connection with the employment of the rubber dam to lessen the discomfort of the patient.

Fig. 198

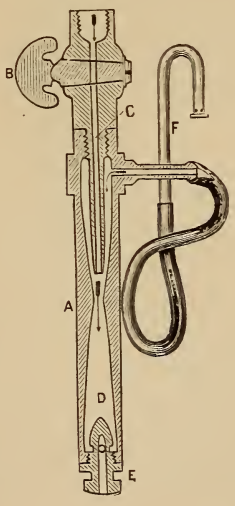
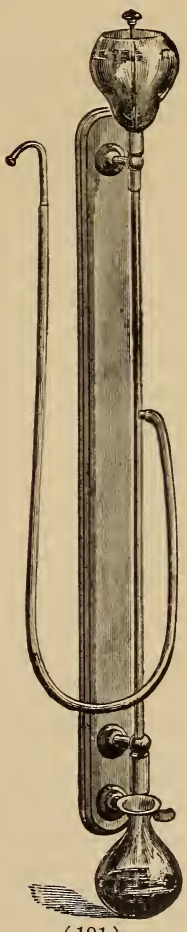


Fig. 199



USE OF THE RUBBER DAM

During the preparation of cavities on the proximal surfaces of the bicuspids and molars where it is essential to have *unrestricted view* and the *exclusion of blood*, the presence of which is inseparable from thorough preparation of the cervical margins, it is necessary to make use of the *rubber dam*. When used for this purpose the material generally becomes impaired by the action of the instruments in their free use at the cervix; but the economy of time and the essentials of thorough performance of this class of operations warrant the application in many cases during this portion of the treatment.

When the case is ready for the filling process, a new piece of the dam should be prepared, and adjusted with great care to prevent the ingress of the least moisture. Without this appliance the greatest skill is powerless to secure sound results in large, difficult, or complicated cases. The introduction of this invention by the late Dr. Sanford C. Barnum has made it possible to secure sterility of the field of operation and to execute with gold, operations which previously were impossible; while not the least advantage resulting from its use is that the operator has free use of the left hand to assist the right.

Quality of the Rubber.—The quality of the rubber greatly modifies the facility of its application. It should be of medium thickness and of light color, as it then absorbs less light. It should be freely extensible, and so elastic that when the thumb is forcibly pressed into it it returns to its normal form on the removal of the force. If it responds to this test it will not tear if fairly applied.

The size and form of the piece should be such as to avoid encumbering the face of the patient and to permit the lateral extension to be folded out of the way in such manner as to prevent obstruction of the view. The form generally best suited is a *triangle*, which form also permits of its most economical use.

For the front teeth the piece should be moderately small; for the bicuspids and molars the size should be ample, and is best adapted when cut from strips about seven and a half inches in width.

The selected piece should have holes cut in it of such size as to correspond with the dimensions of the teeth over which it is to pass. When more than one hole is required, the holes should be at such distances apart as will present a sufficient amount of material to allow for the take-up in the application, so that the strait which passes between the teeth shall be sufficient to allow the edge to be carried upward to form a valve at the cervices of both teeth and not be under such strain as to interfere with the valvular action of the edges of the rubber. At the same time there should be no excess to hamper the view or interfere with the placement of the filling material. Ordinarily two or more

FIG. 200

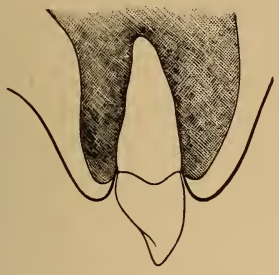
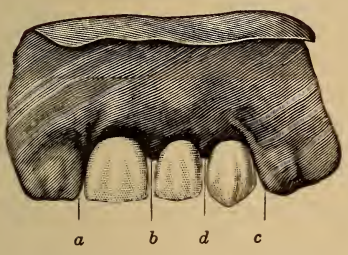


FIG. 201



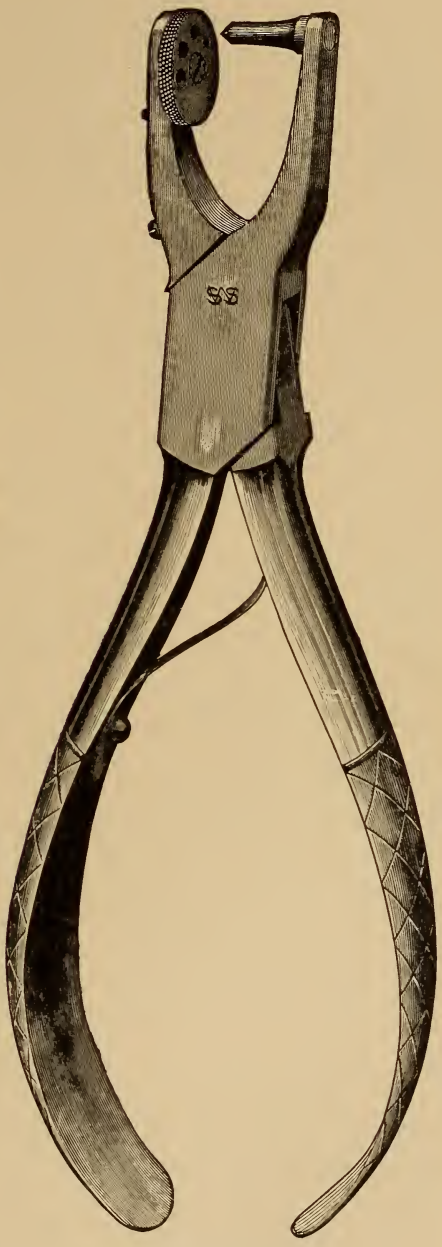
Diagrammatic drawing: form of valve.

teeth on each side of the tooth which is to be operated upon should be passed through the rubber dam to give greater security to its adjustment as well as convenience in operating.

Attention to the valvular arrangement of the dam at the cervix will avoid subsequent difficulty, and will prevent, in many instances, the infliction of pain in using ligatures except upon the tooth under treatment and the adjacent one.

The diagrammatic appearance of this valve is shown by Fig. 200, and in perspective by Fig. 201, *a*, *b*, *c*, *d*.

FIG. 202

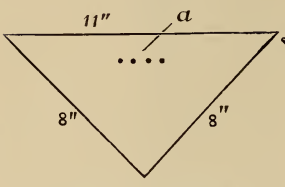


The Ainsworth punch.

The holes in the rubber may be formed with a punch of suitable size, which should be forced upon the end of a close-grained piece of hard wood. They may be made with a little practice by drawing the

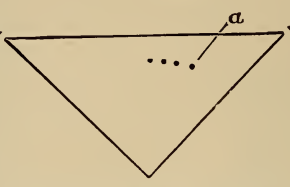
rubber over a round-ended instrument with some force, and pricking the rubber at a suitable point with a sharp knife, when a round section escapes. The difference in size of the holes is determined by the distance from the end of the instrument at which the puncture is made. The determination, however, of size and distance is not easily made in this manner. The best appliance for the purpose is the Ainsworth punch (Fig. 202), with which complete control of size and distance may be easily effected.

Fig. 203



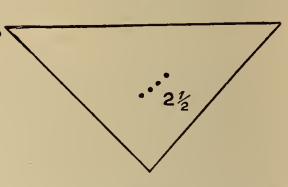
For central incisors.

Fig. 204



For upper bicuspids and molars.

Fig. 205



For lower bicuspids and molars.

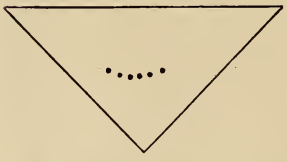
The arrangement of the holes in the triangular piece should differ for each section of the mouth.

Fig. 203 shows a piece for the *central incisors*. The figures represent inches.

Fig. 204 shows the arrangement of holes for the *upper bicuspids and molars*. It will be observed that the line of holes is not parallel with the upper edge.

Fig. 205 shows the arrangement for the *lower bicuspids and molars*. Here, too, the line of holes is not parallel with the edge, to allow for the difference in distance from the commissure of the lips to the anterior and posterior holes.

Fig. 206



For lower front teeth.

Fig. 206 shows the arrangement when the lower *incisors and canines* are included. Here the line of the apertures is curved.

By conforming to these arrangements of the openings in the rubber, and by extending the line in conformity with it, as well as by increasing the size of the piece, any number of holes may be made, to include any portion or all of the teeth of one-quarter of the denture when that may be required.

The number of apertures in the rubber should be such as to give easy access to the operation and to permit the free entrance of light. For the anterior teeth five to six holes are necessary, and for the posterior teeth, from four to six, as may be needed to secure the above-stated objects. In general, at least two teeth anterior to the one operated upon, and when admissible, the one posterior, should be included.

The Placement of the Dam.—When the teeth are not in firm contact, or when their attachments are flexible, the adjustment of the dam is simple. But when the teeth are rigid certain preliminary conditions should be secured. It has been pointed out (Chapter IV) that in the preparation of the teeth for a series of operations, they should be well cleaned of any deposits which may be upon them and be polished on their approximal surfaces. This makes easier the insertion and the application of the rubber.

Generally, when the case under treatment is a proximal surface, the necessary preparatory separation makes easy the immediate opening of any interstices near the operation. In cases of extreme fixation of the teeth a piece of rubber dam placed for a day or so in a couple of the neighboring spaces makes it easy to pass the rubber through the margins of the interstices. The passage of a silver tape with a little benne oil or vaselin on it often answers as an equivalent means. In the front teeth a thin wedge inserted just above a tight point permits an easy entrance.

The preliminary silking of the adjoining spaces, particularly if the silk be coated with vaselin or its equivalent, also facilitates the passage of the rubber, and for this purpose soaping the under surface of the rubber adjacent to the holes is recommended.

At first the novice finds difficulty in making application of the dam, but practice cultivates facility. In general it is better to commence with the anterior hole and proceed posteriorly until all the intended teeth are included. Thus for the left lower teeth the rubber is taken with the index fingers applied to the upper surface, the other fingers to the under surface, and is grasped near the hole for the front bicuspid; the hole is extended; the edge of the rubber is inserted in the mesial interstice and is carried down to the gum. It is then drawn over the tooth and passed into the next interstice in the same manner. This method is pursued with each tooth until all are included. The passage of the rubber is facilitated by helping it downward by the insertion of floss silk, which is held taut, and with a firm and gently sliding movement the rubber is conveyed toward the cervix.

When the most distant tooth is the lower third molar, it is generally best, when the cavity is on either side of the last interstice, to pass the jaws of a dam clamp through the posterior hole; the clamp is then made to grasp the tooth, the dam is conveyed to the gum by waxed floss silk, and the adjustment is then carried forward from tooth to tooth. The same procedure is sometimes applicable with short third molars in the upper denture, or in case any of the posterior teeth are so shaped as not to retain the rubber.

When the rubber is adjusted over the teeth the purpose of the dam is effected by directing the edge of the dam under the free margin of the gum. This is done by passing a silk thread around the tooth, and

crossing the ends, when by a drawing movement of the thread it travels down the inclined surface of the cervix, carrying the dam with it, thus making a more secure formation of the valve.

This method avoids the needless paining of the patient caused by pushing the threads against the gum with instruments. Whenever necessary for security the ligature should be tied. This should be done to the teeth on both sides of a proximal cavity. It is necessary here to place the cervical margin of the cavity in full view and to make certain the exclusion of moisture, which otherwise might pass the valve by capillary attraction.

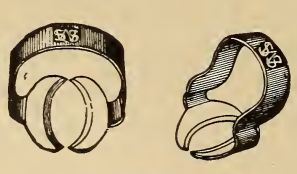
The ligature should usually be passed but once around the tooth and then be tied with a surgeon's knot, the place of the knot being on the outside. When there is much strain the thread may be passed twice around the tooth, but this should be avoided as being more painful and as increasing the bulk of the ligature.

To prevent the rubber from displacement by the movement of the cheeks on the posterior teeth when they are long, if after drying the surface a little sandarac or dammar varnish is applied at the last interstice the rubber becomes fixed.

In cavities extending above the cervix, when a ligature cannot be placed above the cervical border of the cavity, other means have to be adopted to obstruct the entrance of fluids. Here the strait of rubber between the holes should be much wider than usual; the abundant fold may then be forced beyond this margin with a matrix, when, by drying the parts and by the deft introduction of alcohol varnish and suitable wedges, dryness of the parts is attained.

The Securement of the Dam from Displacement.—When the teeth are short from incomplete development, or when their form is tapering from the gum toward the occlusal aspect, there is always a tendency of the rubber to escape, and the contraction of the commissure of the lips tends to the displacement of the dam at the posterior teeth, the latter movement often being sufficient to overcome the friction of the ligatures. When these difficulties arise a clamp is required.

Fig. 207



Dr. Southwick's clamps.

Fig. 208



Dr. Huey's clamps.

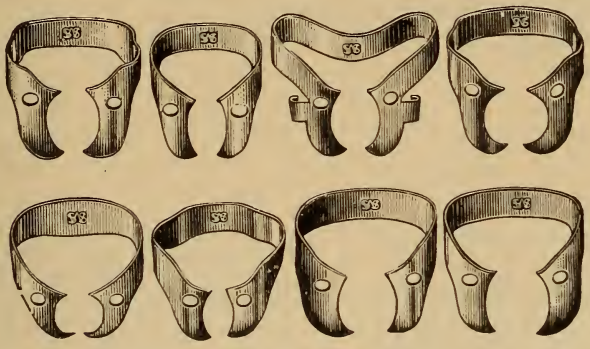
The Clamp.—This is an instrument of much value not only as a means of securement of the rubber, but as an adjunct to prevent the rubber from obstructing the view. Clamps are more especially needed

to detain the rubber on the molars and are rarely required for the bicuspids or the anterior teeth, since, if the foregoing directions are followed, the necessity for their use will but seldom be presented.

Forms of Clamps.—For the molars various sizes and shapes of the "Southwick" and of the "Huey wisdom-tooth clamp" are sufficient for general use. In addition to these, "Palmer's set of eight," after the sharp points of the jaws are rounded, will furnish the requisite variety.

The Application of the Clamp.—The selected clamp is extended by the clamp forceps to enable it to pass over the molar. It is conveyed to the middle portion of the tooth, when the inner beak should be brought against the tooth at the gum margin; then with this point as a fulcrum, the outer beak is carried to the cervix on the buccal surface. Much pain may be avoided in the employment of this appliance by deft and careful placement. Injury of the gum and needless pain has

FIG. 209



Dr. Delos Palmer's set of eight clamps.

frequently been inflicted by careless use of force in the application of this appliance. Much of this may be avoided by the previous ligation of the tooth, which will prevent the tendency of the clamp to descend beneath the gum when the necks of the teeth are much inclined inward.

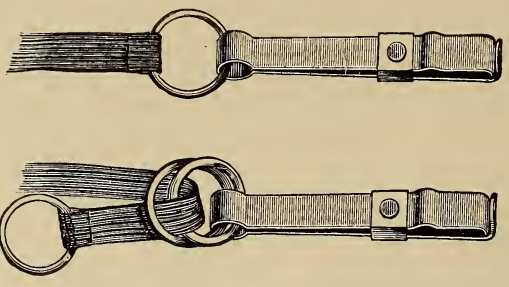
When it is necessary to force the clamp against the soft tissues, the previous application of a solution of cocain will obtund the tissue and render the application bearable.

The Arrangement of the Dam on the Face.—This concerns the convenience of the operator and the comfort of the patient. To give easy access and permit the entrance of light, the rubber is drawn aside at each upper corner by dam holders. The simpler forms of these are sufficient and are more convenient than the more complicated ones when triangular pieces of rubber are employed. In addition a supporter, shown at Fig. 211, passes over the head and engages at each end with the holder. The comfort of the patient is secured by including a

napkin along with the rubber in the clasps of the holder. The excess of the rubber at each side should be taken up in a fold and secured to the napkin by dressing pins. The suspended part of the rubber is kept taut by pendant weights.

The application and arrangement of the dam becomes, by practice, a very simple matter, and should not be the occasion of discomfort or pain to the patient.

Fig. 210



Design of Dr. Cogswell.

Fig. 211



A supporter.

The Use of Napkins.—There are many instances of simple cases in accessible positions not of proximal surfaces, when the general flow of saliva can be kept under control by the saliva ejector, where it is not necessary to use a rubber dam. Also for children, when the teeth are too short to permit the correct application of the dam, it is necessary to find other means to control the moisture. Here the reliance is upon napkins, and with them much skill may be displayed by deft operators. For this purpose the napkin should not be over eight inches square. The manner of folding is to carry two adjacent edges to the diagonal of the napkin, and then fold again in like manner; by this plan the folds are held in place.

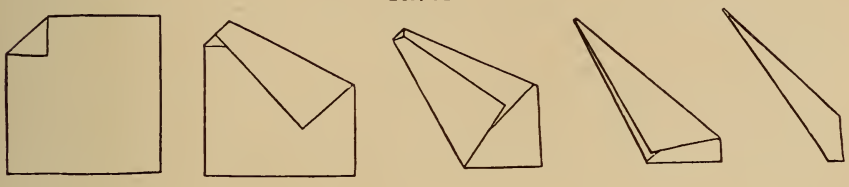
To apply a napkin to the *upper right side*, the point is taken between the left index finger and the thumb, the broad end being held at the same time by the right hand. The lip near the right commissure is everted, the point is inserted here, and by the taut action of the left hand, the napkin is next laid between the gum and the lip. It is then carried backward until it reaches the duct of Steno, when the left index finger is applied to maintain the compression at this latter point. The free end of the napkin lies upon the lower lip. For the left side the action is the same by the reversal of the hands.

For the *lower teeth* the application differs by commencing for each

side at the upper canine of that side. When the duct of Steno is reached, a fold is made to effect the compression of the orifice of the duct, then the napkin is laid between the cheek and the lower teeth, and kept in position by the left index finger, a mirror, or a check-holder.

An important preliminary to the application of a napkin to these positions is that the saliva ejector be first placed in action and that the surfaces of the gum and cheek be wiped to dryness, to cause the napkin to cling to the surface. If the surfaces are covered with mucus and at the same time are wetted with saliva, the napkin easily becomes displaced.

Fig. 212



Aseptic Napkins.—For simple procedures, such as dressings, making examinations, putting in temporary stoppings, and small occlusal fillings, the recently introduced aseptic napkins are very useful. They are folded into triangular shape. The evolution into this form is shown by Fig. 212.

Fig. 213



Fig. 214



In the completed form these may be placed in any convenient manner to assist in protecting many easy cases from the encroachment of saliva. Used in connection with absorbent and non-absorbent rolls they furnish much facility, and do not encumber the mouth or cause distress. Fig. 213 shows the manner of applying the folded aseptic napkin, where it is held in place by an Ivory clamp. In this and similar cases a short piece of non-absorbent roll may be included with advantage at the part opposite the duct of Steno, which by the pressure will occlude this duct.

Similar means may be followed with the lower teeth by placing non-absorbent rolls as appears in Fig. 214. When in connection with an absorbent roll to occlude the parotid duct, uncomplicated occlusal cases are carried on with facility. Hence it will appear the field of work may be upon any of the teeth within the limits of the rolls.

Nausea.—The contact of the rubber dam with the tongue and the contiguous parts, the presence of napkins, and the touch of the fingers to the oral surfaces frequently excite *nausea*. With some persons this kind of distress is extreme and produces simulation of faintness and nervousness. This condition may generally be relieved by the use of *aqua camphora*, a few drams being used as a gargle to the mouth and throat. When indications of faintness appear a dram may be swallowed with immediate benefit.

In case excessive nausea is occasioned by the contact of the appliances with the tongue or palate, these surfaces may be painted with tincture of camphor. Spasmodic coughing, not infrequent with nervous persons, yields to the same treatment. Camphor appears to relieve in these instances by its antispasmodic power, and it is stated to have also a specific action upon the eighth pair of nerves.

Nervousness coming on during any of the operations upon the teeth may as easily and in the same manner be avoided. It will be observed that in neither of these conditions are the first signs of approaching syncope apparent, viz., sighing respiration, pallor, and clammy perspiration of the face.

A condition somewhat simulating approaching syncope, sometimes appears in connection with the use of the rubber dam, due to partially suspended respiration, which is caused not so much by the obstruction of the mouth as by the unpleasant sensations occasioned by the application and presence of the dam. This may at once be overcome by requesting the patient to breathe deeply through the nose.

CHAPTER IX

THE OPERATION OF FILLING CAVITIES WITH METALLIC FOILS AND THEIR SEVERAL MODIFICATIONS

By EDWIN T. DARBY, D.D.S., M.D.

In the selection of a filling material the operator should consider the character of the secretions of the oral cavity, the position of the tooth to be filled, the extent of the diseased area, the physical structure of the tooth, and the strength of the cavity walls. A filling material must possess certain inherent qualifications, the most important of which are adaptability, indestructibility, non-conductivity, hardness, absence of shrinkage, harmony of color, and ease of manipulation. All of these are not to be realized in any one material, and yet some of the more important are to be found in a single metal or in a combination of metals.

Lead, formerly used as a tooth-filling material, possesses the quality of softness and is easy of adaptation, but is readily oxidized when exposed to the air or the secretions of the mouth. Likewise *tin* possesses characteristics, such, for instance, as ductility and softness, low conducting power, and the ease with which it may be manipulated, which place it in the front rank as a preservative of carious teeth, but it is inharmonious in color, and its very softness, which is so desirable in manipulation, is an obstacle to its use upon surfaces where there is much attrition. The *zinc phosphates*, which are composed of zinc oxid and phosphoric acid in solution, form a combination which at first attracted the favorable attention of the dental surgeon as possible substitutes for metallic foil fillings. They possess, owing to their plasticity, ease of manipulation, harmony of color, comparative non-conductivity, and absence of shrinkage, many desirable qualities, but are lacking in one essential qualification, namely, indestructibility.

The silicate cements, which are attracting so much attention at the present time, have some superior qualities over the zinc phosphate cement in that they have more lasting qualities, but they are brittle and the edge strength is poor.

GOLD

Gold, which has been used for about a century, has fulfilled in a more marked degree than any other material or combination of materials the requirements sought for in a filling for carious teeth. It has one or two

objectionable features, such as high conductivity of heat and electricity, and inharmonious color.

Too much stress cannot be laid upon the question of its purity if the best results are to be obtained from its use. While it is claimed by manufacturers of dental gold foil that their products are absolutely free from alloy, it is nevertheless true that but few specimens of dental foil show a fineness above 999. If this standard were always attained the operator would have little cause for complaint. So small a percentage of alloy as 1 in 1000 would not materially affect the working qualities of the product, but when this is increased to 4 or 6 parts per 1000 it manifests itself by harshness and intractability under the instrument.

Great care should be exercised in the preparation of the foil, since so much depends upon its purity and cleanliness. For a detailed description of the process of manufacture, from ingot to the beaten and annealed foil, the reader is referred to an article by a practical foilmaker.[1]

In former times the dental surgeon was restricted to one form of gold for filling. This was foil ranging in thickness from 4 to 10 grains to the leaf, but as the requirements of the operator broadened the art of manufacture increased, and new preparations were offered, until today the most fastidious can find such as will please his fancy: foils ranging in weight from 4 to 120 grains to the leaf; cylinders of various sizes and composed of non-cohesive and semi-cohesive foil; cohesive blocks prepared for use; rolled gold, varying in thickness from No. 30 to 120, and crystal gold possessing great cohesive properties. These are the more important forms in which gold is offered the operator at the present time.

Before entering upon a description of the classes of cases where each of these seems best adapted, it may be well to describe somewhat in detail the peculiar qualities which each form of gold presents when subjected to clinical use.

Soft or Non-cohesive Foil.—Prior to 1854, when Dr. Robert Arthur discovered and promulgated the desirability of cohesive foil in certain cases, the operator used gold which possessed very low cohesive properties. Used as it then was, in the form of large rope, tape, or as cylinders, the property of cohesion would have been a serious objection, since there would be constant danger of the mass clogging and bridging in the cavity, and the cause of many unfilled places along the cavity walls.

The terms *soft* and *hard*, when used to designate the kind of gold, are misleading, since all gold foil prepared from pure gold or gold that is nearly pure possesses great softness under the instrument. The distinguishing characteristics between the two kinds of gold are the inability to make a certain kind of foil cohesive when exposed to a reasonable

[1] American System of Dentistry, vol. iii, p. 839.

degree of heat, and the ability to render another make of equal purity cohesive by the application of a similar degree of heat. It has been claimed by some manufacturers of dental gold foils that they are able to produce from the same ingot samples of non-cohesive, semi-cohesive, and extra-cohesive gold, attaining these physical properties of the material without alloying with other metals. This has led to the belief that, since absolutely pure gold possesses inherent cohesive properties, some metallic salt or other foreign substance has been deposited upon the surface of the leaf of non-cohesive foil which has the power of preventing the union of the surfaces of the foil when contact is sought. It has been surmised that a thin film of iron has been deposited upon the surfaces of the leaf of non-cohesive foil, for the reason that if a leaf of such foil be melted into a globule, it presents a reddish-brown appearance, which is not true of the leaf of cohesive foil when melted as above.

Much of the so-called non-cohesive foil offered for sale is not, strictly speaking, of this variety, as the application of moderate heat will render it quite cohesive. It possesses the softness peculiar to pure gold foil, but it should not be classed with the variety which does not weld with other particles of the same metal except when subjected to great heat.

It has been claimed by some that non-cohesive foil has no place in dental practice—that any tooth which can be filled with gold may be filled with cohesive foil. This statement may be true in the main, but it is also true that many teeth having strong cavity walls can be just as well filled where a large portion of the filling is made with non-cohesive foil, and with a great saving of time. Adaptation, not hardness, constitutes the saving quality in cavity filling.

As most non-cohesive foil is prepared in the form of sheets and is placed in books containing one-eighth of an ounce, the operator is compelled to prepare it in some form suitable for introduction to the cavity. The size and shape of the cavity will be some guide as to the best method of preparing the gold. The narrow tape, the mat, the tightly rolled cylinder, and the roll or rope are the forms best adapted for the use of non-cohesive gold foil.

The *tape* is best made by taking one-half or one-third of a leaf of No. 4 or No. 5 foil, laying it upon a table napkin of medium size folded square as it comes from the laundry; the napkin is then taken in the palm of the left hand, and the foil spatula is placed in the middle of the piece of foil; the hand is then closed tightly, thus folding the napkin, likewise the foil, upon the sides of the spatula. This process is repeated until the tape is one-eighth or one-sixteenth inch in width (Fig. 215).

If *mats* are required, the foil may be folded twice or three times and then folded lengthwise upon itself until mats of any thickness are produced, as shown in Fig. 216.

When non-cohesive *cylinders* are desired, it is better for the operator to make them rather than depend upon the ready-made ones as prepared by the manufacturer, since these are usually loosely rolled and more or less cohesive. The tape is quickly made into the cylinder by rolling it upon a five-sided broach to the desired size. The depth of the cavity is a guide to the width of the tape, and the width of the tape determines

FIG. 215



Tapes of gold foil.

FIG. 216

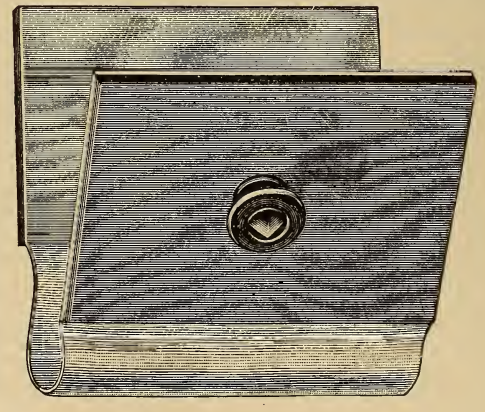


Mats of gold foil.

the length of the cylinder. These should be somewhat longer than the depth of the cavity. The manner of introducing and condensing will be described later when special cases are under consideration.

The *roll*, or "rope," as it was formerly called, is made in the following way: A leaf or half leaf or a third of a leaf of foil is rolled between the thumb and finger until a roll of moderate density is obtained. As foil is contaminated by contact with the moisture and surface impurities of the hands, it is better to avoid such contact as much as possible. This

FIG. 217



Devices for rolling gold foil.

can be completely attained by rolling it upon the little device shown in Fig. 217. Any operator can make one of these by taking two pieces of thin board, such, for instance, as the lid of a cigar box, and fastening to the two pieces with glue a piece of white kid about eight inches in length, and in width equal to the sheet of foil. Two little drawer knobs of ebony or other hard wood should be inserted into the centre

of each of the pieces of board. These act the part of handles for holding the appliance. The gold is first placed upon the kid strip between the lower edges of the covered boards, and by bringing the two surfaces of the kid in contact and rubbing them together with a to-and-fro motion the foil is rolled into a roughly made cylinder. The cylinder is then transferred to the board and further rolled until it is reduced to the desired diameter. The undressed surface of the kid should be the one upon which the gold is rolled. Ropes thus made may be cut in lengths to suit the size of the cavity to be filled, and, as gold thus prepared has great softness and ease of adaptation, it may be inserted in quite large pieces if plenty of condensing force be applied to it.

Cohesive Gold Foil.—All gold which has been refined by any of the ordinary methods and is in a pure state may be said to be cohesive. Nor is absolute freedom from alloy an absolute necessity. It has been shown that softness is dependent upon purity, but a foil may contain quite a percentage of silver, copper, palladium, or zinc, and yet its cohesion may not be impaired. It may also be alloyed or combined with platinum and not lose its cohesive properties. It is, however, desirable that cohesive gold be pure, since the smallest percentage of alloy destroys its softness.

When two sheets or laminæ of freshly annealed foil are brought into contact and slight pressure is applied, they form a permanent union and are practically inseparable. It is this property in gold to which the term cohesive has been applied. But this property is soon lost by the occlusion of gases or impurities of any kind which may be deposited upon the surface of the gold.[1]

Experiments have demonstrated the fact that if the gold be subjected to the fumes of ammonia, hydrogen, hydrogen carbid, hydrogen phosphid, or sulphurous acid gas, its cohesive property is quickly destroyed, but this property may be restored by heat, except in the case of sulphur or phosphorous fumes. Hence the importance of excluding the gold as much as possible from the atmosphere, especially during the winter months, when gases arising from the combustion of coal are most liable to be present in the operating-room.

Dr. Black has shown that ammoniacal gas has the power to prevent the deleterious influence of other gases, and recommends that the foil be subjected to the influence of carbonate of ammonia by keeping it in a drawer with a bottle of that salt.

The *advantages* of cohesive foil cannot be overestimated. With its introduction, in 1855, began a new era in the possibilities of saving carious teeth. Operations which were deemed impossible by the use of non-cohesive foil were made comparatively easy by the intelligent use

[1] G. V. Black, Dental Cosmos, vol. xvii, p. 138.

of cohesive foil. The restoration of broken-down or badly decayed teeth became the common practice in the hands of the skilful, and modern methods of practice, coupled with intelligent use of this form of gold, have made it possible for the operator of modern times to do that which the earlier practitioner deemed impossible.

The beginner, however, must not lose sight of the fact that cohesive foil cannot be worked after the same methods as non-cohesive foil. To use cohesive foil in the form of mats or cylinders or in tightly rolled ropes would mean inevitable failure in adaptation. The very property which renders it valuable in the restoration of broken-down teeth and in surfacing is the one which would condemn it if used carelessly in the interior of inaccessible cavities. Non-cohesive gold may be introduced into a well-shaped cavity in large masses, and because of its softness and ease of adaptation may be made to touch all points of the cavity walls if persistent pressure be applied. On the contrary, cohesive foil should be introduced in small pieces, the first of which should be well anchored in a retaining pit or groove and each subsequent piece welded thereto.

There are several modes of preparing the beaten cohesive gold foil for the cavity, and good results are obtained by either of the following methods:

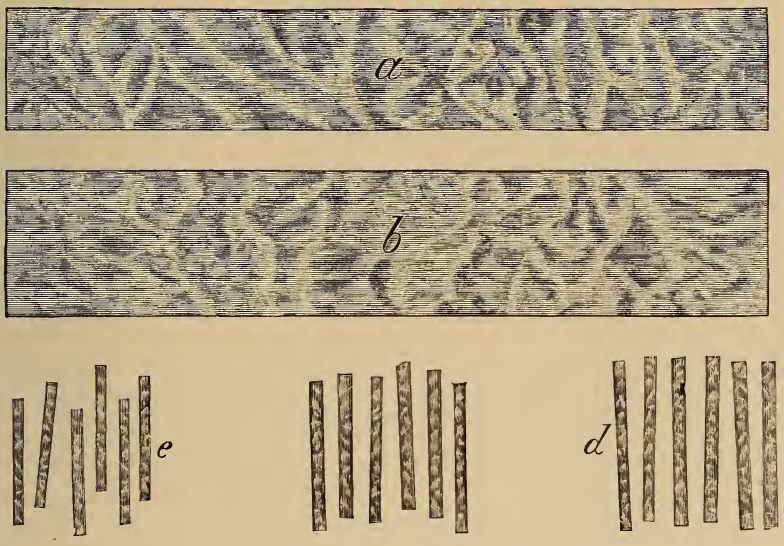
A loosely rolled rope made of a quarter sheet of No. 4 or 5 foil may be cut into lengths varying from one-eighth to one inch, and after annealing, carried to the cavity upon the point of the plugging instrument. Or a leaf may be folded with a spatula four times, making a broad ribbon, which may be cut either lengthwise or crosswise of the ribbon in pieces one-sixteenth or one-eighth of an inch in width (Fig. 218). This is a very convenient manner of working cohesive gold. Or the heavier foil up to No. 20 or No. 30 in thickness may be cut in strips of a single thickness and of the widths above indicated, and after annealing may be packed into the cavity—the essential idea being ever kept in mind, that but a small quantity of the gold shall be under the instrument at a given time. Cohesive gold which has been rolled instead of beaten to the desired thickness is much prized by some. It has been asserted that a greater softness is obtained when gold has been thus prepared. Such gold should not be more than No. 20 or No. 30 in thickness to insure the best results. It should be cut into narrow strips, and, after annealing, be folded back and forth as rapidly only as each previous fold has been well condensed. Good results are only attainable if each lamina be thoroughly welded.

The loosely rolled cylinders and blocks which are prepared by some dealers and offered as cohesive gold are usually but slightly cohesive, and if used in this form, without re-annealing, may be packed in the interior of cavities without danger of clogging; but if freshly annealed they are contraindicated, since there is more or less danger of imperfect

union of all particles of the gold. It is questionable whether the larger sizes are admissible when the filling extends beyond the cavity walls, and great solidity is an essential factor.

Crystal Gold.—This form of gold was introduced by Mr. A. J. Watts in 1853, and as prepared at the present time is one of the best preparations of cohesive gold. When first brought out the method of manufacture was faulty, since it was difficult or impossible to rid the spongy mass of nitric acid, which was used in its preparation, but since Mr. Watts adopted electrolysis instead of chemical precipitation the objectionable features no longer exist. Gold thus prepared manifests great cohesive properties, and when used with care, as beautiful operations can be made with this gold as with any form of cohesive foil. The

FIG. 218



Ribbons and strips

operator should not lose sight of the fact that the gold is to be introduced into the cavity in small quantities. Should failure attend its use, it would doubtless be from the attempt to introduce it too rapidly. Gold of this variety comes in bricks and strips containing one-eighth of an ounce each, and is either torn apart in irregular-shaped pieces or cut by means of a razor into small cubes. This gold should be excluded as much as possible from the atmosphere, and when used should be well annealed, although when recently made it is quite cohesive.

Moss fiber gold is another form of crystal gold, and differs from the variety previously described in that the crystals seem larger, and the mass is not so compact. It may be used wherever a crystal gold is indicated.

Gold and Platinum.—This form of gold has found much favor with many practitioners for the restoration of incisal edges, or where for any reason great hardness of surface is desired.

An ingot or bar of pure gold and one of platinum are "sweated" together and then rolled to the desired thinness, usually about that of No. 20 or No. 30 foil. It is then cut into narrow strips, freshly annealed, and used after the same manner as heavy foil. The commingling of the platinum with the gold gives the filling a tint more nearly the shade of the tooth, and for this reason it is much used upon labial surfaces and in mouths where the teeth are much exposed.

Gold thus combined with platinum is much more rigid than gold alone, and is contraindicated for making the bulk of most fillings. The best results are obtained from it when the mallet is used for its condensation throughout.

ANNEALING GOLD

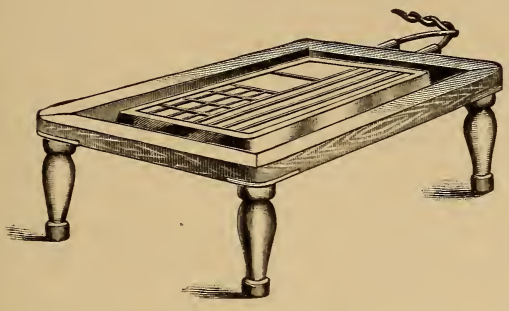
After the manufacturer has reduced the gold to the desired thinness by beating, his last act before booking it is to heat it; this is termed *annealing*. Gold foil which has been recently made and excluded from the atmosphere or certain gases, as previously mentioned, may present sufficient cohesive properties to weld satisfactorily; but this property is soon lost, and re-heating becomes necessary if it is desirable to get union of the various layers.

Most operators make use of an alcohol flame for annealing gold; others a small Bunsen gas burner. Some hold the piece of gold to be annealed in the direct flame or a little above it; others place the gold upon a tray of Russia iron, mica, or platinum, and hold this in the flame of the lamp or gas jet. This latter method is safest, since there are apt to be impurities in the flame dependent upon a charred wick, a particle of phosphorus dropping into the wick from the burning match, or, in the case of the gas jet, imperfect combustion, which might give either carbon or sulphur deposits upon the surface of the gold. All or any of these accidents would impair the working qualities of the gold.

The most satisfactory method of annealing gold is by the use of the electric annealing tray. Such a device has been invented by Dr. L. E. Custer, and is shown in Fig. 219. By this method the gold may be heated to any desired degree and with a uniformity not easily attained by the methods generally used. The working qualities of foil, whether non-cohesive or cohesive, are greatly enhanced by the application of heat at the time of using. Gold that is absolutely non-cohesive is made tougher by annealing and yet its softness is not impaired, while cohesive gold may be made either slightly or decidedly cohesive according as much or little heat may be applied to it. It is the practice of many

operators to use the gold but slightly cohesive when filling cavities surrounded by strong walls, and the gold known as semi-cohesive, in the form of loosely rolled cylinders, is much used. As the filling approaches completion the cylinders are heated and additional cohesive property imparted to them. But when the object is the restoration of contour or building-up of teeth which have been broken, the gold should be heated but little short of redness in order that the greatest cohesive property may be realized.

FIG. 219



Custer's electric annealing tray.

INTRODUCTION OF GOLD, AND THE MANNER OF ADAPTING IT TO THE WALLS OF THE CAVITY

It has been shown in Chapter VII that few cavities are of proper shape for retaining the filling when the decay alone has been removed. Most cavities require to be given a retentive shape so that the filling shall not be dislodged during its introduction or by mastication or otherwise after its completion. In former times, when the operator was restricted to one form of gold, and that the non-cohesive variety, he was compelled to prepare his cavities accordingly; but at the present time, when the variety is almost endless, he can shape his cavity with a view to conserving tooth structure, and when he has given it the desired shape he can select, from the many, a special form of gold that will meet his requirements.

There are certain principles involved in the packing of gold which must be borne in mind, and the operator should study these before introducing his filling. The first of these is the application of *force*, and the direction and relation of that force to the object to be attained. If a given cavity is to be filled with non-cohesive gold, the operator must take into consideration the strength of the cavity walls, and must determine whether by the wedging process which he will exercise in the effort to adapt the gold to the walls of the cavity he will run the risk of breaking them.

Non-cohesive gold is usually introduced by what is known as hand

pressure. Each layer of gold is carried to the floor and the walls of the cavity by a process of wedging, and the mechanical arrangement of each piece of gold should be such that no portion of the gold can escape when the filling is completed. It will be shown later on, when considering the various types of cavities to be filled, that in small cavities of simple shape the gold prepared in the form of tape is best suited, whereas in compound cavities or those of greater size the gold may be introduced in the form of compact cylinders or blocks.

When it is desirable to use a combination of non-cohesive and cohesive gold, the former is generally introduced first and the cohesive is incorporated with it by driving or forcing layers of cohesive into the non-cohesive. This is best effected by using single layers of heavy foil or rolled gold of a thickness equal to 20, 30, or 40 grains to the leaf. If the filling is to be made of but one kind of gold and that the cohesive variety, both hand pressure and percussion by means of the mallet may advantageously be employed. The operator who has learned to combine the two forms of gold and is not restricted to either method of packing is best qualified for the requirements which are presented in general practice. Perfect adaptation to the walls may be effected by either method, but greater celerity and the attainment of equal excellence may be reached by combining the two.

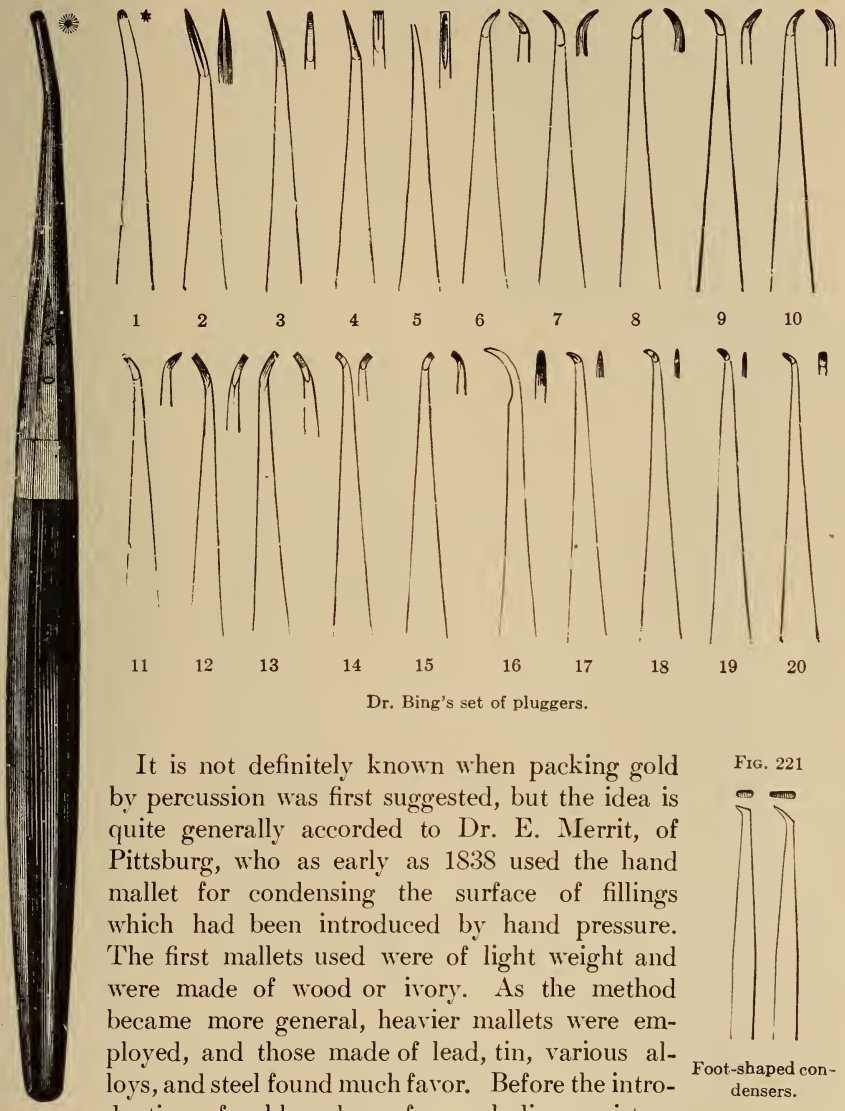
Plugging Instruments.—In the selection of instruments for packing gold the operator should have a sufficient number to meet his every need. They should be of such a variety of patterns that every part of every cavity, however remote, can be reached with ease. It is a mistaken notion that a large number of instruments (if well selected) is confusing. The operator should study his instruments and know their uses as thoroughly as he knows the letters of the alphabet, and if this be done and they be arranged in an orderly manner in his case, the confusion will be manifest in their absence, not in the possession of them.

For packing non-cohesive foil none are better adapted than the set shown in Fig. 220, made from patterns furnished by Dr. B. J. Bing. This set should be supplemented by a small and a medium-sized foot-shaped condenser (Fig. 221) for packing cylinders, mats, or blocks against the gingival wall.

The handles of instruments used for packing non-cohesive foil should be of such size that they can be grasped firmly in the hand. When made of wood they are light in weight and agreeable to touch. Plugging instruments should have as few curves and angles as is consistent with the ability to reach all points in the cavity. As these are multiplied, direct force is sacrificed. The point of the instrument should be as nearly as possible in a line with the shaft. Deviations from this rule are sometimes necessary in order to reach all points in the cavity. Most plugging instruments have serrated points and are used for all forms of gold. As a rule, these serrations should be shallow, and when cohesive

gold is employed they should be only sufficient to prevent slipping, as gold that is quite cohesive packs as readily with smooth points as with rough ones.

Fig. 220



Dr. Bing's set of pluggers.

Fig. 221

Foot-shaped condensers.

It is not definitely known when packing gold by percussion was first suggested, but the idea is quite generally accorded to Dr. E. Merrit, of Pittsburg, who as early as 1838 used the hand mallet for condensing the surface of fillings which had been introduced by hand pressure. The first mallets used were of light weight and were made of wood or ivory. As the method became more general, heavier mallets were employed, and those made of lead, tin, various alloys, and steel found much favor. Before the introduction of rubber dams for excluding moisture one hand of the operator was employed in holding the napkin, and it became necessary to have an assistant at hand to do the malleting. This led ingenious minds to discover some means of percussion besides the hand mallet, and several spring instruments known as automatic pluggers were introduced. The Snow and Lewis, the Foote, and the

Salmon found greatest favor, and all of them were good of their kind. Fig. 222 shows the Snow and Lewis automatic mallet as made at the present time. When pressure is applied to the point of the instrument a spring is liberated which throws a plunger forward with great force, which is expended upon the gold beneath the point. The impacting quality of this blow is not excelled by any of the mechanical devices in use. It is so constructed that a light or a heavy blow can be given at will. The operator will do well to adjust the instrument for light blows when using it in close proximity to frail or delicate walls, as there is more or less danger of fracturing them.

Instruments of this class are not well adapted to packing gold in the posterior teeth of the lower jaw, as the blow is delivered at a more or less obtuse angle, and unless care be exercised when the operation is nearing completion the plugger point will slip from the surface of the filling and wound the soft tissues.

Another instrument of this type, devised by Dr. Frank Abbott (Fig. 223), has a socket at either end of the hand-piece, the one giving a pushing and the other a pulling blow. The latter is serviceable for condensing gold upon distal surfaces.

The electric mallet is one of the most ingenious devices employed in dentistry. The first practical application of electromagnetic force for dental malleting was made by the late Dr. W. G. A. Bonwill. Its latest development is shown in Fig. 224. This instrument has found great favor among dentists for packing cohesive gold. Its blows are delivered with great rapidity and with such force that great solidity is attainable. A pair of electromagnets transforms the electric current into electromagnetic force, which is transmitted to the hammer. The electric current is furnished by a Bunsen or Partz battery, or the controlled current from a dynamo or storage battery can be used as the motive power. The direct dynamo current of 110 volts can be so modified by the use of a rheostat that its use may be employed, and the trouble incident to keeping a battery charged avoided. In the hands of a skilful operator there could be nothing better for packing cohesive gold. The best results are obtained by its use when the gold is prepared in thin laminæ or where a single thickness of heavy foil or rolled gold is employed.

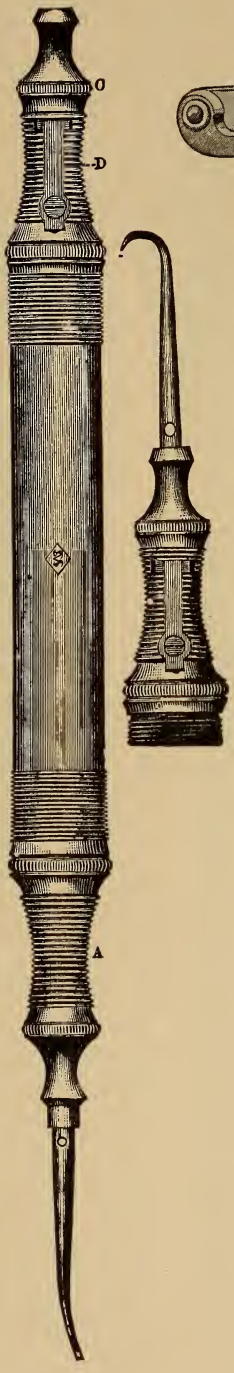
Considerable experience is necessary to enable the operator to use this instrument with satisfaction to himself and his patient. If the plugger point be pressed hard against the filling, the blows, which are delivered with great rapidity and force, become painful and distressing and there is also danger of chipping the cavity walls. The better plan is to hold the point slightly away from the surface of the filling and allow the momentum which is given the instrument by the falling armature to complete the union of the various pieces of gold.

Fig. 222



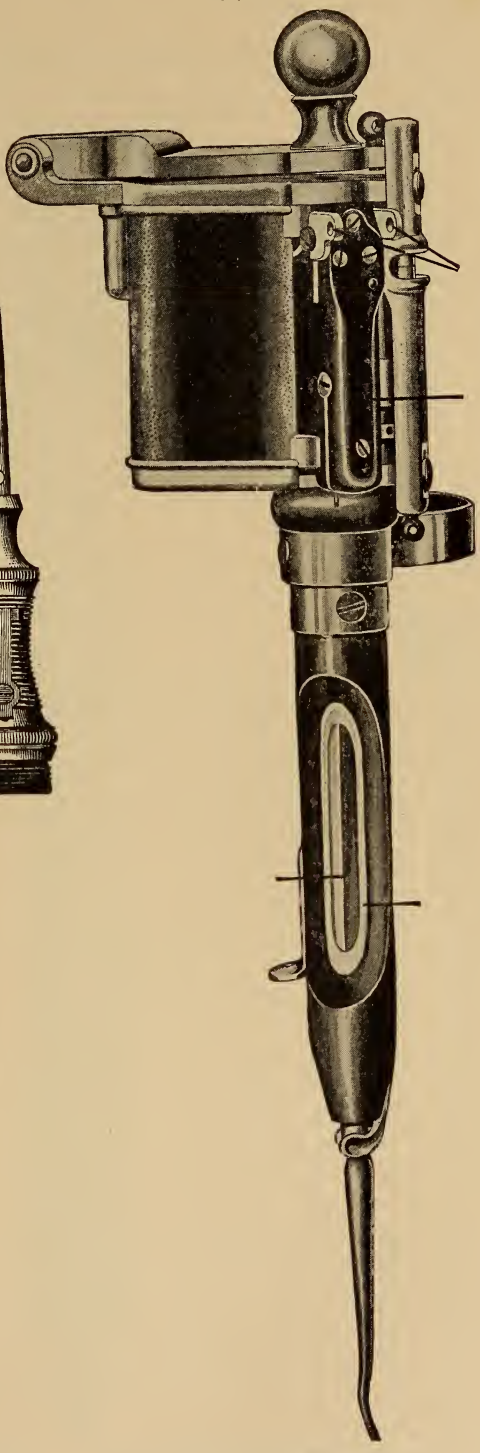
Snow and Lewis automatic mallet.

Fig. 223



The Abbott mallet.

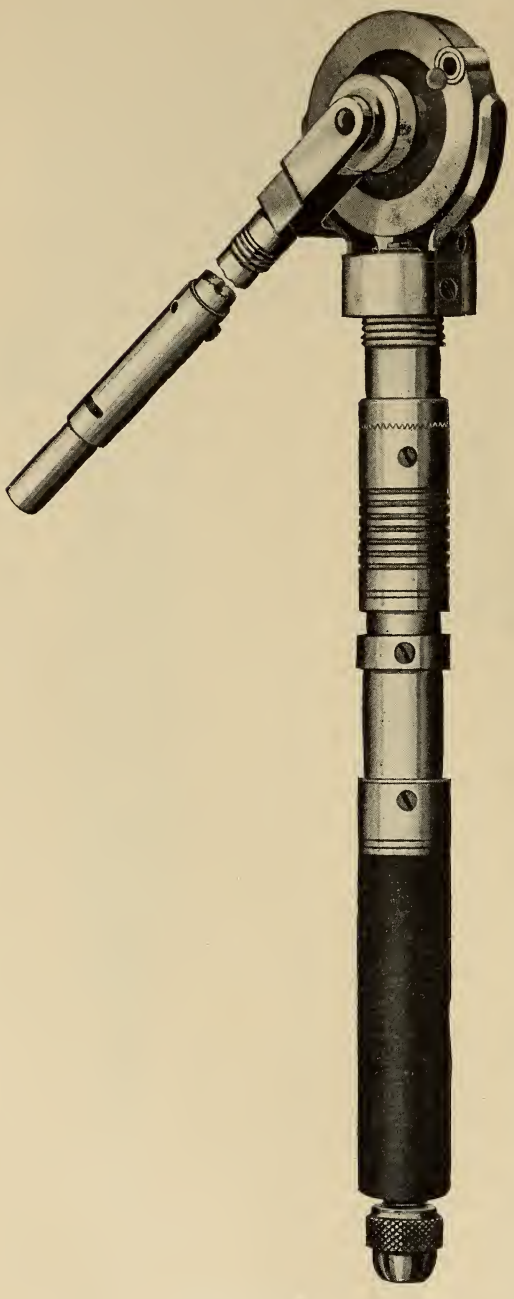
Fig. 224



S. S. White electric mallet "No. 2." Founded on the "Bonwill."

The engine mallet (Fig. 225), known as the "Bonwill mechanical mallet," should be used upon a cord engine only. Much of the disfavor which has attended its use has been owing to the fact that it has been applied to cable engines, and for which it is not in any way adapted. The instrument shown in the illustration embodies many improvements in construction which have been suggested by various operators, and a point of relative perfection has been reached where are combined great efficiency with compactness and lightness in handling. It will be seen by the illustration that the essential feature of this instrument is a revolving wheel, having inserted in its periphery a hollow cylindrical steel roller. This constitutes the hammer. It gives an "elastic" not a "dead" blow, as it is held to its position by a stiff steel spring. The roller revolves slightly in its socket at each contact with the plunger. When the engine is run at ordinary speed the wheel revolves with great velocity, delivering upon the head of the plunger as many as fifteen blows per second. The force of the blow can be modified at will by an extremely simple contrivance, as follows: The interdigitations seen around the upper end of the sleeve are held together by means of a

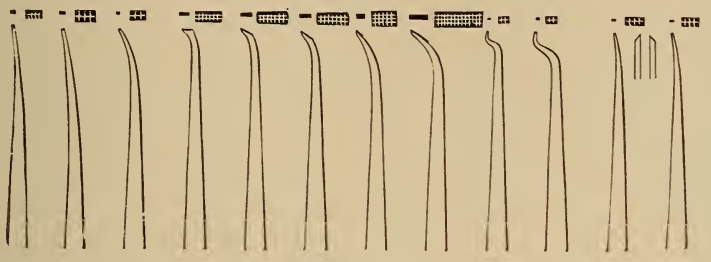
Fig. 225



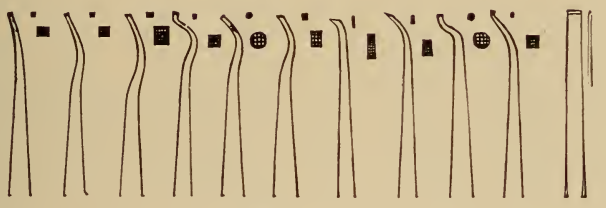
Engine mallet.

spring attached to the sleeve. Pulling the sleeve away from the head against the spring, and revolving it to the right or left, raises or lowers the head of the plunger. Upon releasing the sleeve the spring at once throws it back to engage with the head, and the blow is heavier or lighter, according to the direction in which the sleeve has been revolved. The impacting power of the blow from this is great, and in the hands of an experienced operator a large quantity of gold can be condensed in a short space of time. When cohesive gold foil is employed smooth

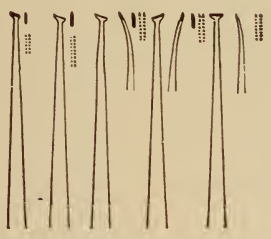
Fig. 226



Varney·s set.



Webb's set.

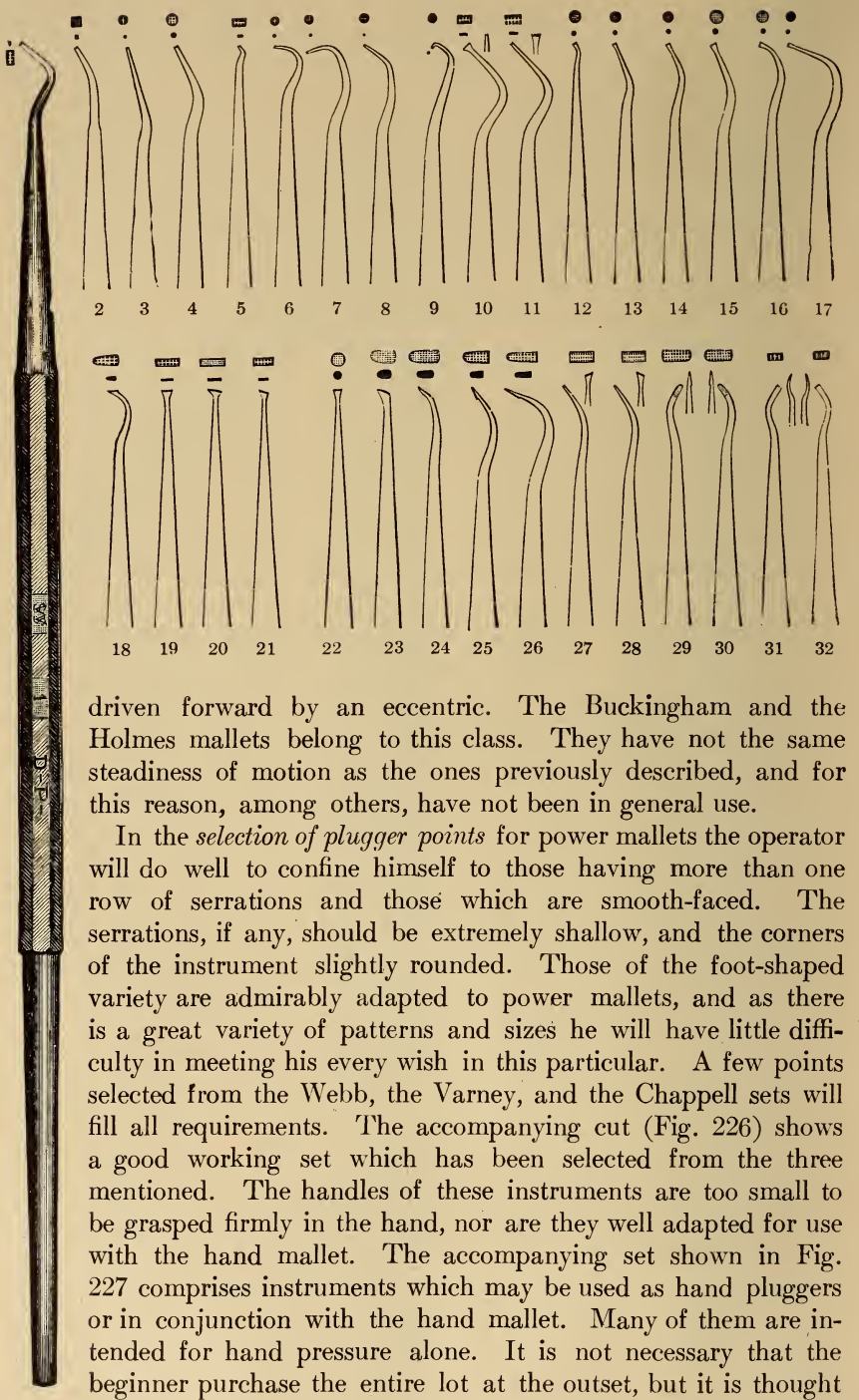


Chappell's set.

oval points may be used with most satisfactory results. The point should not be pressed hard against the filling, but a skimming or smoothing motion given to the instrument. The surface of the filling when thus packed has a polished or planished appearance as if done with a hand burnisher. Such fillings are usually of great density.

There are other mechanical mallets intended for use on the engine which have what is known as a "cam" movement. They are not, strictly speaking, mallets, for the instrument is pushed rather than

FIG. 227



driven forward by an eccentric. The Buckingham and the Holmes mallets belong to this class. They have not the same steadiness of motion as the ones previously described, and for this reason, among others, have not been in general use.

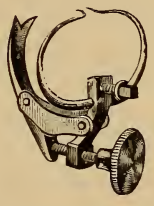
In the *selection of plugger points* for power mallets the operator will do well to confine himself to those having more than one row of serrations and those which are smooth-faced. The serrations, if any, should be extremely shallow, and the corners of the instrument slightly rounded. Those of the foot-shaped variety are admirably adapted to power mallets, and as there is a great variety of patterns and sizes he will have little difficulty in meeting his every wish in this particular. A few points selected from the Webb, the Varney, and the Chappell sets will fill all requirements. The accompanying cut (Fig. 226) shows a good working set which has been selected from the three mentioned. The handles of these instruments are too small to be grasped firmly in the hand, nor are they well adapted for use with the hand mallet. The accompanying set shown in Fig. 227 comprises instruments which may be used as hand pluggers or in conjunction with the hand mallet. Many of them are intended for hand pressure alone. It is not necessary that the beginner purchase the entire lot at the outset, but it is thought that with this combination his every need will be filled.

FILLINGS BY CLASSES

Class A: Smooth Surface Cavities, Cavities in the Gingival Third of Labial, Buccal, and Lingual Surfaces of the Teeth.—Most cavities upon the smooth surfaces of the teeth are simple in form in that they have four walls surrounding them.

There is some difficulty in filling such cavities if the gingival wall of the cavity is above the gum line, and a fold of its membrane extends into the cavity. In such an event it is better to press the gum away with gutta-percha or some similar substance and postpone the filling with gold until absorption shall have taken place, which in most instances will require only a few days, or at most not more than a week or two. If the overhanging gum tissue is not too great it may be cut away with a sharp bistoury, and the operation completed at the same sitting. However, in most instances the rubber dam can be applied, and by means of a Woodward clamp (Fig. 228), held in position throughout the operation of inserting the filling.

Fig. 228



Woodward clamp.

If the clamp is not at hand, the same thing may be accomplished, but with a little more effort, by using a straight instrument, the end of which has been made round and sharp by honing it on an Arkansas oil stone. The dam is then raised well above the gingival wall of the cavity and the point of the instrument pressed well into the cementum and held with the left hand throughout the filling of the cavity.

No effort should be made to force a ligature above the gingival border of such cavities, for such a procedure would not only wound the gum where it dips low into the interproximal spaces, but would be liable to set up an irritation in the gingivæ and possibly in the peridental membrane, and would also, in the nature of things, be attended with failure.

It is always well when filling such cavities to include in the rubber dam at least one or more teeth on either side of the one being operated upon.

Cavities of this order are usually shallow and need no resistance form, and what little retention form they require is to be found in the point angles.

If cohesive gold is used for starting the filling (and it is usually indicated), the point angles at the axio-mesial and axio-distal walls should be deepened into a convenience or starting point and the first piece of gold thoroughly fixed therein, after which the remainder of the filling may be added without danger of rocking or rolling in the cavity. The operator should learn early that where a filling is to be made of cohesive gold alone, his first piece must be securely anchored; otherwise he will be building upon an unstable foundation and his operation will prove a failure. If, on the other hand, it is thought best to start the filling with

gold that is non-cohesive, or with soft mats, or cylinders, known as semi-cohesive, he may lay a foundation upon the axial wall, forcing the gold well into the point angles, and, after partially condensing, work some cohesive gold into the mass, completing the filling with gold that has been freshly annealed and made quite cohesive. These cavities are so exceedingly simple when the rubber is held securely above the gingival wall of the cavity that failure to make a good operation would be rare. Nevertheless, the operator must not overlook the importance of packing his gold in the direction of each of the four walls, that it may be thoroughly bound into the cavity by these walls. Great care should be exercised not to batter or injure the cavo-surface angle. A sharp, well-defined border adds materially to the artistic appearance of such fillings. As gold fillings upon labial surfaces of the teeth are usually conspicuous, it is often well to fill such cavities with platinous gold, because the tint of the two metals in combination is more nearly the shade of the tooth; especially is this true in teeth of yellowish hue.

While decay upon the labial surface of the incisors and cuspids does not often extend over the labio-mesial or labio-distal angle of the tooth, it does sometimes happen that the cavities upon the proximal surface of the teeth extend so far labially that, for the good of the tooth, the frail wall of enamel is better cut away, making the two proximal cavities confluent with the one on the labial surface. In such an event, the mesial and distal cavities may be filled with gold and a porcelain inlay inserted in the labial cavity if necessary. A little of the gold may be cut away in shaping the cavity for the inlay.

Fig. 229



Fig. 230



Class B: Cavities in the Proximal Surfaces of the Incisors and Cuspids Which Do Not Involve the Incisal Angle.—These are shown in Figs. 229[1] and 230. If space between the teeth has been made previously, only by a mechanical separator at the time the cavity is being prepared, the gold may be inserted at once. It must be borne in mind that all fillings upon proximal surfaces, wherever located, are to be given full contour, or made to touch, at or near the point of original contact. This is one of the fixed laws of a creed that is rigid, and as reasonable as rigid. Satis-

[1] Illustrations 229 to 239 are reproduced from Dr. Black's Operative Dentistry and are used in this chapter through the courtesy of the Medico-Dental Publishing Company.

factory results can only be obtained by having sufficient space between the teeth. The beginner requires more space than the experienced operator, and even a little more than is actually needed is far better than not enough, because many a contact point has been cut away in finishing the filling because of lack of space, which, if had at the time, would have enabled the operator to add a little more gold at the contact point. Fillings of this order should be made throughout with cohesive gold. The foil may be prepared in a rope which has been made from one-half, one-third, or one-quarter of a sheet of No. 4 or No. 5 cohesive foil, and then cut into lengths of one-quarter, one-half, or even an inch. It should be freshly annealed, preferably in an electric annealer, and then laid on a tray, covered with white kid or something similar, from which it may be lifted with the foil carriers or plugger point. If the cavity be on the distal surface of the tooth, and the labial and lingual angles have been cut equally, and the approach from the embrasure be equally good, it matters little which convenience point is filled first. Most operators prefer working from the labial approach. To this end, therefore, the first piece of gold is carried into the linguo-axio-gingival convenience point, and held there by an instrument in the left hand until the gold can be gathered into the angle by the use of the hand plugger. The first piece must be thoroughly seated, with no tendency to rock or move, after which one, two, or more small pieces may be added to it, and the mass well malleted with the hand, automatic, or mechanical mallet. It is then well to fill the opposite convenience point in labio-axio-gingival angle, working from the lingual approach. After a similar amount of gold has been placed in this angle, a piece of gold should be laid across from one angle to the other and packed well against the gingival wall. The building of gold across this wall should be done with utmost care. The piece should not be so large that there will be any clogging in failure to reach every portion of the wall. Frequent gentle malleting is indicated. The gold should then be carried along the lingual wall, gradually working toward the incisal angle, being careful all the time that the fulness be maintained in the direction of the gingival third. When the retention point in the incisal angle has been reached, a right-angle plugger should be used to carry the gold into that portion of the cavity. Unless there be great space between the teeth, this retaining pit should be *made* and *filled* with right-angle instruments. The effort to do this with a bur in the engine is liable to undermine the enamel, and to attempt to fill it with a straight instrument or one nearly so, and by mallet force is liable to result in an imperfect operation, if not the fracture of the incisal angle of the tooth.

When the incisal angle has been filled, attention should be given to the labial wall (Fig. 231). The gold should be packed toward this wall as it has been toward each of the other walls, ever bearing in mind the form of the finished fillings. Small, foot-shaped pluggers of

the Varney and Webb variety will be found useful in restoring the contour of the filling. The operator must be careful throughout the operation of packing gold, and especially when employing mallet force, that he keep a mass of gold constantly between his instrument and the enamel wall, lest he chip and fracture that wall, giving it a ragged or serrated appearance. The gold should be given great solidity, otherwise it will not take that beautiful finish so important in all gold fillings. There seems to be a notion, more or less common, that gold cannot be made solid unless it be packed exclusively by mallet force. This is an error and one that has led to many imperfectly filled cavities in the incisor teeth. More labor is required to condense a given amount of gold by hand pressure, but as great solidity can be obtained by it, and there is not the same danger of chipping enamel walls when the hand plugger is used in inaccessible portions of the cavity.

FIG. 231



Class C: Cavities in the Proximal Surfaces of Incisors and Cuspids Which Involve the Incisal Angle.—The method of introducing the gold in this class of cavities does not differ materially from those just described, in so far as the gingival third of the cavity is concerned. It does not matter whether the filling be started in the linguo-axio-gingival convenience point or in the labio-axio-gingival point. The operator should be governed by circumstances. If his approach be better from the labial than the gingival side of the embrasure he will preferably fill that point farthest away first, and that will be the linguo-axio-gingival. This form of anchorage is applicable to teeth of broad incisal edges or in teeth which have been purposely made broad upon their incisal edges for the purpose of gaining this form of anchorage.

After the two gingival anchorages have been filled and the gold well malleted, additional pieces of gold are added, until the gold has been packed across the gingival wall and that portion of the filling brought out to its greatest distal or mesial fulness or against the proximating tooth. The gold is then built along the linguo-axial wall, as shown in Fig. 231, until the incisal step is reached; then along the pulpal wall into the angles which have been made by the inverted cone bur, being careful that each of these point angles has been thoroughly filled and the gold made solid therein. When this has been accomplished, a sense of security may be felt that the gold will not be dislodged. The direction of the plugging instrument must be constantly in a general line with the long axis of the tooth, and at no time should an angle of less than 12 centigrades be used. It should also be borne in mind that the force should incline in the direction of the wall to be filled. The only way to accomplish that is to drive it in that direction. Gold is often driven away from rather than toward the tooth. When the filling has progressed thus far the shape of the tooth may be restored, working

gradually from the gingival third toward the middle and incisal third, ever bearing in mind the form of the filling at the point of contact. Much of the final packing of gold may be done with small foot-shaped pluggers. Before removing the rubber dam, or even before a burnisher has been used upon the surface of the gold, a careful inspection of all the walls should be made, to be sure that at no point has there been a failure to get sufficient gold. Special attention should be given to the incisal angle. A failure to fill every point along the cavo-surface angles would result in early failure of the filling; also, great hardness is needed here; otherwise the surface of the gold will be battered by the opposing tooth. Platinoid gold is sometimes indicated upon the incisal edge because of its greater hardness.

Class D: Cavities in Proximal Surfaces of Bicuspids and Molars.—It will be seen by reference to cuts of these prepared cavities in Chapter VII that there is great similarity in the form of cavities in the bicuspids and molars. The convenience form has received so much attention that there is nothing particularly difficult in the introduction of the gold. If the teeth have been previously separated, or if a mechanical separator is to be used for effecting space, the operation of introducing the gold should follow immediately upon the excavation of the cavity.

There are two methods of starting fillings of this type: The first is to fill the cavity throughout with cohesive gold; the other, to use a combination of non-cohesive and cohesive gold. We will describe first the method of filling throughout with cohesive foil. The preparation of the gold for cavities of this description does not differ materially from that previously described in proximal cavities of incisors and cuspids. A roll made from one-third or one-half leaf of gold may be cut into pieces ranging from one-quarter to one inch in length. When the gold has been annealed, the first piece is carried to either the bucco-axio-gingival or the linguo-axio-gingival point angle, which has been deepened into a convenience point for starting the filling. It matters not which of these points receives the first piece of gold, provided they are equally accessible. If, on the other hand, one is easier to reach than the other, the one most remote or hardest to reach should be filled first. The instrument *a* (Fig. 232) in the left hand should hold the gold while it is carried into the starting point with a hand plugger *b*. This first piece of gold must be thoroughly seated, after which two or three pieces may be added to this and the same malleted to place. The opposite point (Fig. 233) should be similarly filled, and then a piece laid across the gingival wall and connected with that in the two-point angles (Fig. 234). Several pieces should be added until the gold has covered the entire gingival wall and has been built out nearly or quite across the interproximal space to the adjoining tooth (Fig. 235). It is at just this point that so many failures occur. The gingival third of the cavity

must have special attention. The cavo-surface angles must be thoroughly covered. Special attention should be given the filling mesio-distally. Carry the gold out to the adjoining tooth even though it may seem at the time that too much gold is being added. Piece by piece should be added until the occlusal step has been reached. The operator should hold his plugger at such an angle that the gold is being constantly driven against the buccal and lingual walls of the cavity, as well as against the gingival. As soon as the building of the filling has reached the occlusal step it is well to cover the pulpal wall and build back and forth into that which has been placed against the axial wall. If the central fossa has been included in the cavity and is deep, it is sometimes well to fill this before covering the

FIG. 232

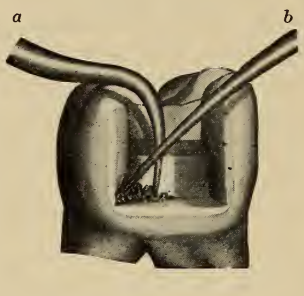


FIG. 233



FIG. 234

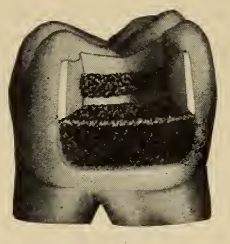


FIG. 235



entire pulpal wall, as it gives the operator a sense of security lest by any means he dislodge the gold already inserted. A few pieces joined in this way and well malleted will insure stability. From this point onward attention should be given to the proper contour of the fillings. If additional space is desired, a turn or two of the screw of the separator may be made. It is better to have rather more space than is actually needed than to find, when the operation has been completed, that not enough gold has been added to make a perfect contact point. The advantage of thorough malleting at this point cannot be overestimated. The gold should be solid, not only upon the proximal surface, but upon the occlusal. Any defect along the margin means a leak and ultimately a failure of the filling. Perfect adaptation and great hardness are two

essentials in all fillings of this class. The other method of starting these fillings, as above alluded to, is to fill the gingival third of the cavity with non-cohesive gold, used in the form of cylinders or blocks. This method has the advantage of greater rapidity and as great, or greater, protection to the tooth along its gingival wall. The writer would not assert that better fillings can be made by this method, but in the hands of one who has become skilled in the use of non-cohesive gold much time can be saved, and experience has shown that fillings are equally as good as those made throughout of cohesive foil. A half leaf or No. 4 non-cohesive foil is folded into a tape or ribbon until its width is a little greater than the depth of the cavity from its axial wall mesio-distally. This tape is wound upon a flat instrument for an oblong cylinder or a five-sided broach for a round cylinder. It matters not which, because the cylinder is flattened either before or after it is introduced into the cavity. One end of the cylinder is placed against the axial wall, the other projecting somewhat beyond the gingival wall into the interproximal space. It is usually better to have this cylinder broad enough (Figs. 236, 237, and 238) linguo-buccally to press upon these walls and be forced into the

Fig. 236



Fig. 237



Fig. 238



bucco-axio-gingival and the linguo-axio-gingival angles. If a single cylinder is used, it should contain a considerable quantity of gold, and after being matted down in a general way with a broad-faced plugger, then a piece of cohesive gold should be carried into the bucco-axio-gingival and the linguo-axio-gingival point angles, taking with it a portion of the cylinder which has been mashed against the buccal and lingual borders of the cavity. An instrument in the left hand will aid the operator in holding the cylinder in place until he has made it secure in the point angles, as above. The mallet may now be used and the gold thoroughly condensed against the gingival wall, after which cohesive gold should be used to complete the filling. Another method of using non-cohesive gold in such cavities is to use three cylinders, placing one toward the buccal, one toward the lingual wall, and then one between the two which acts as a key. As the middle one is forced toward the gingival wall the others are pressed laterally, after which the cohesive gold is inserted as above described.

When filling distal cavities of the class under consideration, the

matrix is often used. It is thought by many to simplify the starting of the filling. One end of the cylinder rests against the matrix, the other against the axial wall. It unquestionably does assist in holding the cylinder within the cavity and makes the seating of the filling much easier. If the matrix be made of thin copper and securely lashed to the tooth with floss silk and wedged securely against the gingival border of the cavity, it does answer a good purpose and may be used to advantage, but as great care is necessary when packing the gold around the cavo-surface angles, and perhaps greater danger of imperfections at these points than when no matrix has been employed. In mesial cavities, the matrix obstructs the light and should seldom be used, except when amalgam or one of the plastics is to be used as the filling material.

Special consideration should be given to the manner of packing the gold in this class of cavities, and in fact in all cavities which are to be filled with gold. A hap-hazard way, with a thrust here and a blow from the mallet there, does not make fillings of uniform density, nor does it make fillings with tight margins. After placing a piece of gold at a certain point, the whole surface of that piece should be gone over with the plugger point step by step, each move of the plugger point being not greater than its own diameter. It would be well if the operator could have in mind an imaginary line drawn bucco-lingually through the centre of the cavity being filled and from that central line direct his force axio-lingually and axio-buccally (Fig. 239). When the cavity to be filled is as far back as the distal surface of the second molar, direct access to such cavities is difficult, especially in the lower teeth, and to get direct force with pluggers of a single curve is impossible. Much of the packing of gold in these cavities must be done by hand pressure, or by the use of the reverse plugger and mallet force. It is thought by many that the matrix is indispensable in cavities of this kind, but unless great care be taken, imperfect margins will be the result. If amalgam were the material under consideration, the matrix would be most useful and always indicated.

The process of packing gold in these large cavities, unfavorably located, is, in the nature of things, slow, but if good and lasting results are obtained by the use of gold, each step in the operation must be painstaking and thorough

Class E: Small Cavities on Occlusal Surfaces of the Bicuspids and Molars.—These are among the simplest in form and may be quickly filled with gold of the non-cohesive variety, if used in the form of tape, or with the machine-rolled cylinders found in the dental depots and known as semi-cohesive. Those in the bicuspids are usually regular in form and need no additional resistance or retention shape. When the cavity has been four-fifths filled, cohesive gold should be used for surfacing, and if throughout the operation mallet force has been used freely, a thoroughly good filling will be the result. Cavities of this character, although of

greater size, are found in the molars, and may be filled in the same general way. Mats of foil may be substituted for tape; or, where the cavity is very large, the gold may be introduced in the form of cylinders. It not infrequently happens that a large portion of the occlusal surface of a molar is lost by decay and that the four walls surrounding the cavity are strong. Such cavities may be filled, with a great saving of time, by the use of cylinders. Before the introduction of rubber dam, when the dentist was obliged to control the saliva by means of the napkin alone, time was a great consideration, and cylinder filling was more generally practised then than now. Excellent results can be accomplished by this method, and it were well if the young men who are now entering the profession would learn to use non-cohesive gold, but it is better that the beginner first become proficient in the use of cohesive gold lest he become confused in his attempt to learn too many methods at the outset. Cylinders for such cavities (Fig. 240) should be hand-made and of

FIG. 239

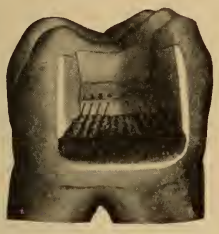


FIG. 240



Occlusal cavity with cylinders.

No. 4 non-cohesive foil. They should be long enough to reach from the pulpal wall to a sixteenth of an inch above the occlusal surface of the tooth. The first one should be placed at the most distal point in the cavity, then cylinder after cylinder is placed around the walls until the buccal, lingual, and mesial walls are covered. Each one in its turn is pressed against the walls with strong wedge-shaped instruments. As often as room can be made in the centre of the mass, another cylinder should be placed, and the same lateral pressure applied. When no other cylinders, not even the smallest, can be forced into the filling, the surface of the gold should be thoroughly condensed by the aid of the mallet, and this repeated until a very hard surface has been secured. This method is better suited to mortise cavities with flat pulpal walls, and the four other walls parallel, or nearly so.

From the foregoing classification of cavities and the special manner of treating each class, the reader may infer that all cavities which are to be found upon the proximal surfaces of teeth, no matter what may be the conditions surrounding them, are to be extended buccally and lingually, gingivally and incisally, until the greater portion of the proximal surface of the tooth has been cut away. But such is not the intention in every

case. The rule is to place all cavity margins on areas that are practically immune from caries, but that zone of immunity is not the same in all teeth, and it is for this reason that the writer would depart from the habit which has become quite general, namely, sacrificing a larger amount of tooth structure than is demanded for the preservation of the tooth. Reference is made to the exceptionally small cavities that are sometimes to be found in the anterior teeth (incisors and cuspids) at or near the point of contact. Experience and observation have shown that there are certain teeth which have small points of contact and open embrasures in which the initial decay is small and has been slow in its progress, with no tendency to spread over an area larger than the head of a small pin. To cut the entire mesial or distal surface away that the rule may be observed is wanton destruction of tooth substance, and in thousands of instances uncalled for. The writer has seen fillings placed in these small cavities which have lasted fifty years or more, with no recurrence of decay. If the dentists of a half-century ago could fill such cavities with non-cohesive foil and make the tooth good for a life-time, surely the dentist of today, who understands the nature of caries, and the means of preventing it, who has grasped the principles of susceptibility and immunity, and, in addition thereto, has the benefit of the increased facilities in operating, surely better results, if possible, may reasonably be expected at his hands. This is a plea for small cavities in the anterior teeth, in which the structure is good and the embrasures broad. Such cavities may be shaped in the same general way as those heretofore described, and may be filled, either with non-cohesive gold, in the form of tape, or with cohesive gold, prepared in any form desired; the lingual and labial walls left intact, or, if it may seem best, the lingual angle may be cut away and the approach to the cavity be from the lingual surface

FILLING WITH TIN[1]

It is not definitely known when tin was first employed for filling carious teeth, but it has been used for at least a century and has found great favor with many. Prior to the improvement in the formulas of dental amalgams, tin was used more generally than at the present time.

Tin possesses certain inherent characteristics which make it valuable as a filling material. Among these are great malleability, non-conductivity, and it is thought by many to possess antiseptic properties. But while it has desirable qualities, it has also some undesirable ones, such as softness, and when exposed to the secretions of the mouth it discolors—which facts render it unfit for surfaces exposed to great wear in the act of mastication and upon surfaces exposed to view. The

[1] The physical and chemical properties of tin in connection with its use as a filling material are discussed in detail in Chapter XI, p. 319.

discoloration, however, is confined to the surface, and teeth filled with tin are not discolored in consequence of its presence.

There are various methods of preparing tin for dental purposes. That which has found greatest favor in the past is in the form of foil. The tin used should be chemically pure. An ingot of the metal is rolled into ribbon and then beaten, after the same manner as gold foil, into sheets of the desired thickness. As a rule, it is not beaten as thin as the former. The foil best suited for most fillings is No. 4.

Pure tin, like pure gold, is cohesive, and fillings of considerable solidity can be made if the operator will exercise care in packing it. The best results are obtained by taking a third of a leaf of No. 4 foil and rolling it into a loose rope, then cutting it into lengths of half an inch or less and packing each piece with a view of making each part of the filling solid. Some prefer holding the sheet with a spatula after the same manner as gold foil, and then cutting into narrow tape. Equally good results are obtainable by either method.

A more rapid but less satisfactory manner of introducing the filling is to use the tin in the form of cylinders, not relying so much upon the cohesive properties of the metal. The directions for using gold in the form of cylinders will apply equally well for inserting tin foil.

Shavings of Tin.—The cohesive property of tin is best illustrated when it is used in the form of freshly cut shavings from a revolving ingot of the metal. Any operator can prepare his own shavings and have them fresh daily or hourly, if necessary, after the following method: Take an ordinary corundum wheel two inches in diameter and one-half inch in thickness, such as is used in the laboratory. Make a mould of this in sand or marble dust, then melt in a crucible or ladle enough *pure* tin to fill the mould. When it has been poured and cooled, mount accurately upon the mandrel of the laboratory lathe, and from it, with a sharp carpenter's chisel, turn shavings of great tenuity. When freshly cut, and before oxidation of the surface has taken place, by exposure to the atmosphere it will be found that the tin coheres with the same readiness that pure gold does. Broken-down teeth can be built up by this method, or by means of it surfaces may be contoured as with gold.

The plugging instruments best adapted for tin filling are those having shallow but well-defined serrations and points not too broad. As the margins are approached, broader points and condensers may be used, and the surface should be well burnished. The operator must not lose sight of the fact that while tin possesses many desirable qualities and is easily manipulated, it lacks hardness and is not adapted to surfaces where great attrition occurs. Its chief value is found in its use upon surfaces concealed from view and shielded from wear, and in the temporary teeth, where its greatest value is manifest.

Tin fillings should be finished with the same care as gold ones, and the same directions will apply in all particulars.

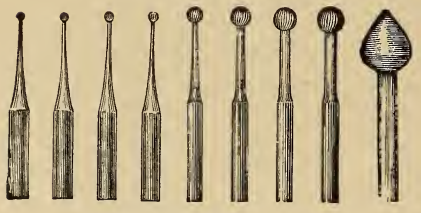
FINISHING FILLINGS

Much of the beauty and utility of a filling depends upon the way it is finished. It is not enough that it be well made; it must be well finished, if the best results are to be attained. All fillings should contain rather more gold than it is intended shall remain, and this for the purpose of dressing down to such lines as shall be both practical and esthetic.

Fillings that are not solid and well condensed throughout their entire surface cannot be given a fine finish.

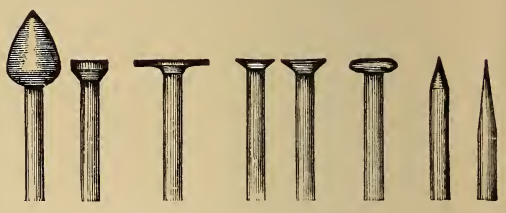
After the last piece of gold has been added and the whole surface of the filling gone over with a plugger with shallow serrations or with no serrations at all, a thorough burnishing with a burnisher that is *absolutely* smooth, should be given the surface of the filling. By this means the gold is made more compact and the margins are sure to be well covered. This does not mean that imperfect margins can be made good by a burnisher, but a good thorough burnishing brings the gold in absolute contact with the enamel margins.

FIG. 241



Plug finishing burs.

FIG. 242



Wood polishing points.

The small fillings upon occlusal surfaces (and all pit and fissure cavities) are best dressed down with finishing burs, as shown in Fig. 241. They are finely cut and leave the gold with a more uniform surface than when cavity burs have been used for the purpose. The gold should be cut away until the cavo-surface angle has been reached, and until all overlapping of gold has been removed. The occlusion of the tooth of the opposite jaw should be noted, and if it strikes unduly upon the filling, enough should be taken from the surface of the gold to prevent it. When a uniform surface has been given to the gold, a suitable wood point, as shown in Fig. 242, should be mounted in an engine mandril made for that purpose and the point dipped first in water and then in fine pumice powder and the surface nicely smoothed. After which a round-end burnisher may be used, if the operator desires a polished surface, although it adds nothing to either the beauty or the utility of the filling.

When fillings cover a larger portion of the occlusal surface, the cutting of the gold may be done with corundum or carborundum points and wheels, which, if kept constantly wet, cut more rapidly than burs

and cause less heating and less discomfort to the patient. These are shown in Fig. 243, and are of many patterns, and admirably adapted for the purpose intended. Those made of fine corundum and shellac, or corundum and vulcanized rubber, are more desirable than the coarse ones, which are liable to grind away the cavity margins because of the rapidity with which they cut.

Fillings upon labial and buccal surfaces should be dressed down with fine stones, such as the Hindostan, or any variety that has fine grit, until the outline of the cavity is reached. Any overlapping of gold upon these surfaces gives a ragged appearance to the filling and detracts much from its beauty. Care should also be exercised in giving the filling the same degree of convexity that the tooth formerly had—in other words, the filling should accurately restore the lost anatomical contour of the tooth.

FIG. 243



Corundum points.

FIG. 244



Hindostan points.

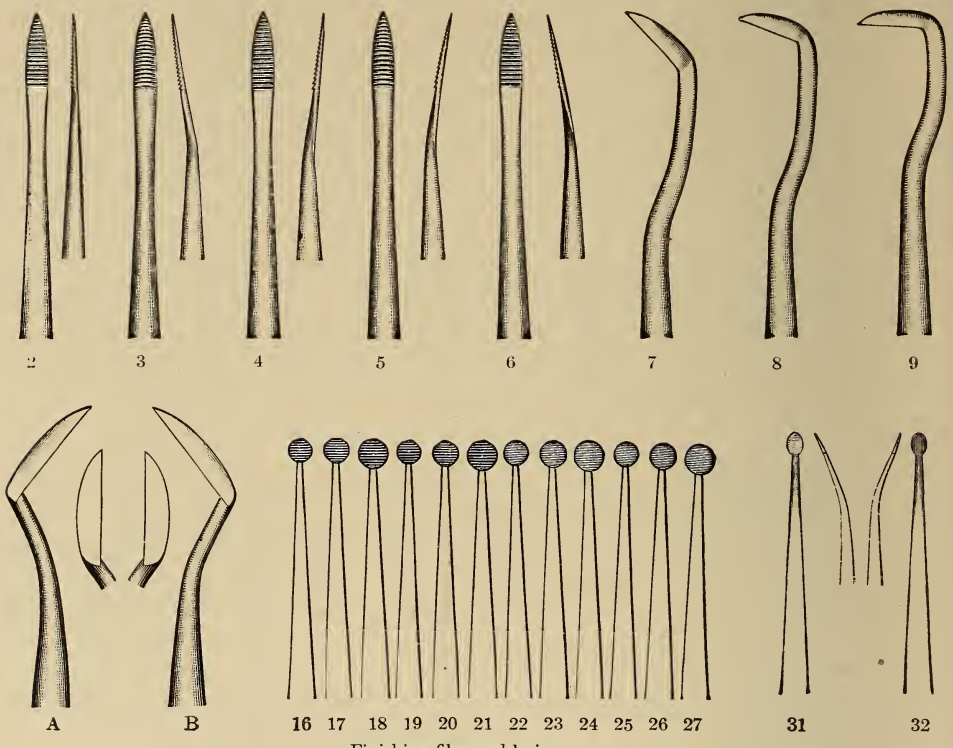
When sufficient gold has been removed the surface should be nicely smoothed with revolving wood points, charged with pumice powder and water, or a paste made of pumice and glycerin, after which the final finish may be made with flour of pumice, chalk, or oxid of tin, used by means of a revolving disk or wheel of felt, leather, or rubber. As fillings upon the labial surface are more or less conspicuous at best, it is better not to give them a burnished surface. The "dead" or satin-like finish which is left by the flour of pumice is usually preferred.

Fillings upon proximal surfaces are more difficult to finish, and too great care cannot be bestowed upon them. An operator is often judged by the finish that he gives his proximal fillings, and justly so, as no class of fillings requires a higher degree of skill in the finishing.

In olden times, when no effort was made to restore the natural contour of the tooth, fillings were made flat, and a file was about the only instrument required in the finishing of such fillings; but the day of flat fillings has passed, and the separating and finishing files of our fathers have little use in the cabinet of the present-day dentist. The whole method of

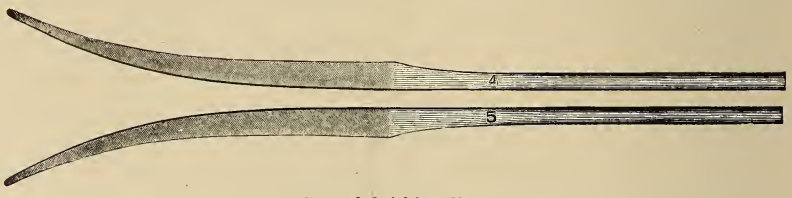
finishing fillings upon proximal surfaces has changed, and a new line of instruments suited to this method has been evolved. There is of necessity more or less overlapping of gold in the insertion of a filling, and the removal of all excess is as important as any other part of the operation. For this purpose a variety of instruments is supplied. In the selection of

FIG. 245



Finishing files and knives.

FIG. 246



Curved finishing files.

these the operator should bear in mind that he has a *contact* point to preserve, and he should avoid the use of such instruments as may cut away the thing of greatest importance, and the one most liable to be destroyed. To this end, separating files are practically to be eliminated, but in their stead gold trimmers of various patterns are to be used. In Fig. 245 are

illustrated some of those most useful. The gingival wall is generally the one to receive attention first, and if the conditions are such that the separator and rubber dam can be left in place until the gold which overlaps at the gingival borders has been trimmed away it will add much to the ease of finishing that portion of the filling. It is well in all instances to retain the separator as long as it can be done without interfering with one's ease of manipulation, because it is often desirable to lift the teeth apart a little for the purpose of passing thin finishing strips between, although, as a rule, it is better to pass nothing between the points of contact, or what is to be the point of contact, until nearly the last thing. The knives and finishing files shown in Fig. 245 should be used for cutting away any overlapping gold at the gingival wall of the filling; also for dressing down the lingual and buccal borders. A finishing strip may be *threaded* through the interproximal space above the proposed point of contact and worked back and forth. Sometimes as many as a half-dozen pieces should be used in getting the gold down to the walls, but it should be understood that these finishing strips are not to be passed back and forth from the occlusal surface, and that their use at this stage is to be confined to the gingival third of the embrasure. Attention may now be given to the lingual and buccal margins. If the filling extends well toward the lingual and buccal angle (and it is to be presumed that it does) a disk of corundum may be used very cautiously for cutting down the greater portion of the overplus gold, but in the hands of a beginner it is safer to confine one's self to the hand files and trimmers. The same may be said of the sandpaper disk if used too freely. The one point above all others is to avoid cutting away the contour which has been laboriously made, and so destroy the contact point, which is of vital importance in the comfort of the patient and the future welfare of the tooth. Under the most favorable conditions, the finishing of fillings in the proximal surfaces of the bicuspids and molars is slow, often consuming as much time as the insertion of the filling, but when done with care and the result which has been attained it is well worth the time and effort expended. Attention should now be given to the proximo-occlusal angle and the occlusal surface. At this point stones, revolving in the handpiece of the engine, may be used, but they should be so shaped that they will not by any possibility cut away the gold unduly from the proximo-occlusal angle. When the gingival third of the filling has been finished and the contact point preserved, the rubber dam may be removed, and the further dressing down of the occlusal and proximo-occlusal surfaces done with a wet wheel, which lessens the friction, and consequently the heat, which is often distressing when using burs or wheels of any kind in a dry state. Special attention should now be given to the articulation of the filling in occlusion with the teeth of the opposite jaw. If the contact be with the gold, it should be cut away until the patient notices no undue pressure upon any portion of the filling. A filling

just a little too full is unpleasant to the patient; one *much* too full is a cause of danger to the filling and surrounding walls, and possibly to the pulp or pericementum. Before the final smoothing of the filling is done with fine powders, one last attention should be given to what will be the future point of contact. It is presumed that up to this time every other portion of the filling has been dressed into final shape, and it is possible to do all of that with the trimmers and other means provided; then, as a final touch, before using the buffing wheels, a strip charged with fine buckhorn or silex may be passed a few times over the contact point, and from that moment nothing more than a smooth burnisher should touch it. If, however, the separator has lifted the teeth apart sufficiently, and the operator is assured that he has space to spare, he may pass back and forth between the teeth a piece of thin linen tape, first made wet and then charged with some fine polishing powder, such as chalk, oxid of tin, or buckhorn. When this has been done, and the occlusal portion has received the same careful treatment, the filling may be considered finished. Burnishing adds nothing to its appearance or utility, and if in a position to show, only makes it more glaring and manifest. The same general treatment in the matter of finishing fillings upon proximal surfaces of the incisors and cuspids obtains and a special description here is unnecessary.

REPAIRING FILLINGS

Fillings somewhat defective are often susceptible of repair. The defect may sometimes be apparent in the finishing; at other times it is the result of subsequent caries, and at still other times the result of a fracture of the enamel along the border of the filling.

The nature of the defect and the condition of the remaining filling must be taken into consideration before an effort to repair is undertaken.

When the defect is due to insufficient gold at any point in the filling more gold may be added. It is well to first cut out a portion of the filling, making a distinct cavity of retentive shape. Cohesive gold is usually best suited to the purpose; crystal gold often serves well in the repair of such defects.

If the filling has been thoroughly condensed and the mass is solid there is little difficulty in adding more gold to it, provided the surface be clean. If it has been wet with saliva, the surface of the gold must be made not only dry, but clean. It is well to wipe it with a pellet of cotton or paper saturated with absolute alcohol or ether, after which the filling should be scraped with a suitable instrument. If the filling be of considerable size and well anchored, shallow retaining points may be drilled into it, which will make an additional hold for the gold which is to be added. Defects which arise from subsequent caries are perhaps

more frequent in proximal surfaces at or near the gingival margin. These borders are vulnerable points for the recurrence of caries, and imperfect adaptation is not infrequently the determining cause of the beginning of such decay.

To effect a successful repair in such localities ample space should be obtained, especially so if the repair is to be made with gold.

If the decay has not extended beneath the filling, and sufficient space has been obtained, there is no greater difficulty in making a successful repair than in filling a simple cavity similarly located. If the operator is skilled in the use of non-cohesive gold, he will do well to prepare his foil in the form of narrow tape, and work it into the cavity fold after fold, allowing the loops to extend somewhat above the walls of the cavity. When the cavity has been completely filled the protruding folds may be well condensed and the filling finished in the usual way; or the repair may be made with cohesive gold, the first piece having been made fast in a groove or retaining point.

Such repairs are often required in the bicuspids and molars, and large fillings otherwise good are saved by a successful repair at the cervix. The plastics are sometimes indicated in this class of cases, provided they be not so near the anterior part of the mouth as to be unsightly. Gutta-percha often serves a good purpose here, but in some mouths undergoes decomposition and is less reliable than gold. The oxyphosphates are contraindicated because of their liability to wash away after a few months. Amalgams are more frequently used, and nearly always serve well when thus employed; but unfortunately the contact with gold produces discoloration, and an unsightly filling is the result. Whenever gold and amalgam are brought in contact in the same tooth, if the surface of each is exposed to the fluids of the mouth, the amalgam is almost sure to turn quite black. The discoloration of the surface of the alloy does not lessen its value as a preserver of the tooth, but its unsightliness is often too great to be tolerated; nevertheless, utility enters so largely into the equation that the operator feels justified in using the alloy, because with it he feels sure of making a better repair. After the alloy has hardened it should be nicely dressed down and all overlapping of the material at the gum margin removed, when it should be smoothed and polished with the same care that other fillings receive.

Fracture of one or more of the cavity walls is a common accident, and one which may be repaired if the filling has been securely anchored in portions of the tooth not involved in the fracture. Such accidents sometimes befall bicuspids and molars, especially the bicuspids, where fillings have been inserted in each proximal surface, the two meeting upon the occlusal surface. The buccal wall is sometimes the one broken away, sometimes the lingual. In either case the ability to successfully repair depends upon the stability of the proximal fillings and the anchor-

age which can be obtained at the gingival wall and in the exposed fillings. To restore with gold a buccal cusp or the entire buccal surface of a bicuspid might necessitate a show of gold which would be objectionable; and a better plan would be to engraft a porcelain facing or an entire porcelain crown; whereas such a restoration on the lingual surface would not be open to the same objections. Cohesive gold alone is indicated for repairs of this kind. Watts' crystal gold when used in cases of this description has been most satisfactory.

If the fracture extends above the margin of the gum the operation is much more difficult because of the danger from a flow of blood, and the additional difficulty of getting the rubber dam above the border of the fractured surface. This may be accomplished by filling for a few weeks with gutta-percha, when there will be recession of the gum caused by the pressure of the gutta-percha upon it. When a similar fracture occurs in a molar, if the fractured surface does not encroach upon the pulp, and will admit of drilling retaining points without danger to the pulp, there is no difficulty in restoring the broken portion with cohesive gold. Mack's screws are sometimes indicated in cases of this kind, since strong anchorage can be secured in this way without much loss of tooth substance.

Fracture of the incisal angle of the anterior teeth is often a serious accident, because of the difficulty of repair and the unsightly display of gold when it has been accomplished.

Large fillings situated upon the proximal surfaces of the incisors but not extending to the cutting edge, yet near enough to weaken the enamel overhanging, are especially liable to need repairs. The corner of the tooth breaks away, leaving the surface of the gold exposed, and the only hold the filling has is at the gingival border. In order to secure retaining hold for additional gold the operator must be careful not to displace the original filling. A wooden wedge should be inserted between the teeth and pressed home with sufficient force to hold the filling securely in place during the operation of repair. Sometimes a retaining point can be made laterally into the sound dentin, or, by cutting a little channel through to the lingual surface and then deepening the channel at its extremity with a round bur, a secure anchorage may be had for the fresh gold.

Great care should be exercised in packing the gold, lest by inadvertence the instrument should slip and push the original filling from its position. Fractured surfaces should receive prompt attention, for if left for a period of time disintegration of the dentin will set in and the caries may extend beneath the filling and thus jeopardize or ruin the most thorough work.

CHAPTER X

USE OF THE MATRIX IN FILLING OPERATIONS

By WILLIAM CRENSHAW, D.D.S.

The matrix, as originally suggested and employed, was used exclusively between the molars and bicuspids, and consisted of curved pieces of thin metal of various kinds, which were braced with wooden wedges from one tooth to the other; but now the matrix has been adapted to other teeth and other forms of cavities, as will appear in the further development of this subject. All forms of cavities occurring on molars, bicuspids, and incisors, standing alone or together, excepting those cavities located in the occlusal surfaces of the first-mentioned class, and in the cutting edges and corners of the latter, are now subject to the use of the matrix as an aid in filling them.

The large and difficult filling operations encountered between the molars and bicuspids, which in past decades so taxed the skill and vitality of the dentist, have been by various forms of device rendered easier of execution and more permanent and perfect in character.

Matrices have been used more or less in one form or another for the past fifty years, and some crude forms even longer. Dr. Louis Jack gave the profession thirty years ago the first practical idea and demonstration of the matrix and its possibilities, and his effort, more than all that had gone before, gave shape and impetus to the development of this important device.

GENERAL CONSIDERATIONS

The limitations, no less than the possibilities, of the matrix are important to understand, because, used indiscretely, in locations which the judgment should forbid or in locations where it would be perfectly in place but for the unsuitable nature of the material employed, more harm than good may result from its use. To be able, therefore, to discern the proper class and location of cavities for the reception of the fillings, together with a knowledge of adapting the filling materials to the case in hand, are some of the requirements and demands on the operator who essays to use matrices.

The matrix should possess as fully as possible the qualities of adaptability and fixedness to the teeth, at the same time provide for contouring and for leaving the teeth in proper position, and preserving the proper

interproximal space. Further desiderata are that the matrix shall be resistant enough to stand the pressure of condensing gold against it, susceptible at the same time of being shaped into whatever form needed, and capable of being removed from between the teeth without destroying the form of the filling after that has been completed.

The material of which the matrix is made depends somewhat on the location and class of the cavity to be filled.

In many of the operations occurring between molars and bicuspids, particularly in the instances where only one tooth is decayed and only slightly so, slips of German silver or steel (36 to 40 gauge) may be interposed and used. In the instances where gold is to be the filling, and the cavity is of large size, the metals above mentioned, silver and gold plate, but of heavier gauge, and other substances may be employed. But in the event of the matrix band having to bear heavy tension, which tests the strength of it, as in the loop or band variety or any duplex form which separates the teeth, either decarbonized steel or phosphor-bronze, the tensile strength of which is equal to or beyond that of steel, should be used. Steel is somewhat unsatisfactory, because if bent often at one place it breaks, and it does not hold polish or plating well. Phosphor-bronze not only polishes and holds plating well, and does not corrode, but solders readily to gold, silver, German silver, steel, copper, and brass, and does not soften or amalgamate with the mercury employed in amalgam alloys.

The matrix band should be closely adapted around the margin of the tooth cavity, and the cavity floor and walls coming up to the band should form as nearly as possible right angles with the band. This rule followed, with the employment of proper forms of instruments, will be found to insure well-condensed margins, and as full a contour as ordinarily belongs to the tooth of its class; and, in those instances where it is desirable, greater contour than belongs to the tooth may be produced.

Those devices which when assembled are practically in one piece, and admit of easy application and steady fixedness on the teeth, with as little of obstructing parts as possible, are the ones with which the operator will ordinarily accomplish best results. The bands should not purposely stand away from the tooth. This is impracticable even if it were desirable, as there are no means for holding the band away from the tooth and at the same time having it secure from slipping and working loose under the operation of the filling. Occasionally in cavities occurring on the mesial side of upper first and second molars, and more frequently on both the mesial and distal sides of upper first bicuspids extending well under the gum, we encounter the concavity occasioned by the bifurcation of the roots, when of necessity the band stands off from the depression. The filling, however, whether of gold or tin foil, is not better condensed at this point for that reason.

The failures made with the matrix result quite frequently from the selection of a wrong material. Take, for instance, any of the proximal

surfaces of the molars or bicuspids in which the cavity extends beyond the margin of the enamel, presenting ideal conditions for the employment of the matrix; prepare these cavities after approved methods, apply the matrix, and fill with any form of cohesive gold, and we have a filling beautiful in appearance, but more treacherous than beautiful, and one which will develop recurrent decay along the cervical margin sooner than would result from the employment of any other filling material placed in the permanent list.

It will not matter what form of cohesive gold is employed, if heat sufficient to change its molecular arrangement has been applied in annealing the gold, it is practically impossible to adapt it, unaccompanied by linings, so as to secure moisture-proof joints, and therefore permanent results. Because, first, the tooth does not afford the resistance necessary to reduce the crystals of gold into adaptable laminæ, and we have the crystalline gold resting on fibrous structure in the cementum and dentin, which together prevent the making of moisture-proof joints. Therefore, this state of affairs, aided either by the creeping in of fluid at the base of the filling from the canaliculi and lacunæ, or drawing in external moisture by capillary attraction from without, permits of recurrent decay. With cohesive gold, the result would be ultimately the same, with or without the matrix; although the work would, should at least, be better executed without it. But with the cavity well prepared, and the matrix securely adjusted, the operation is inviting in appearance, and the operator is led into a snare and delusion when he essays to fill these points with cohesive gold exclusively.

The objection here raised to cohesive gold does not apply to the same extent in adapting it to enamel walls, because in this tissue we have an absence of nerve fibers, and a greatly denser substance against which to adapt the gold. While it is impossible to adapt cohesive gold to tooth structures so as to stop out moisture permanently, for the reason pointed out, there is that difference in the histological make-up of the tissue of cementum and dentin and enamel which explains the fact of cohesive gold being better adapted to enamel, and can be made to better prevent the leaking of moisture than in cementum margins. Again, decay cannot be so rapid in enamel margins, because of its inherent strength and resistance, due in part to the absence of nerve fibers and to its greater density and hardness.

The propaganda of Prof. Henry S. Chase—namely, that in proportion as teeth need saving gold is the worst material with which to do it—is true in its application to cohesive gold, particularly in cementum and dentin margins in connection with the matrix. But substitute non-crystalline or soft gold in these margins, and we pass from the worst possible work done with gold, and made even worse by the employment of the matrix, to that which has proved the best possible—at least up to the present time.

Cohesive gold is at its best in open cavities with strong enamel margins, and is profitably employed in cervico-occlusal fillings in connection with soft gold and matrices to cap over the proximal wall of soft gold. Cohesive gold, on the other hand, is at its worst in connection with matrices when used at the cervical margins, particularly when the margin is located in cementum or dentin, because of the physical difficulties encountered in the adaptation of it, and the perishable nature of the margins on which it is laid.

Again, in the employment of a carelessly formulated and compounded amalgam alloy packed into these cavities embraced by a matrix, depending too much on the matrix, as is the tendency, we have another instance in which the inefficiency of this device is made to appear.

It should be made a rule of practice in employing the matrix to regard it simply as a mechanical device, the object of which is to simplify compound and other difficult cavities; and not to depend on it to make good any of the essentials of the filling material. With this idea in view, and fortified by a knowledge of the essential characteristics of materials rather than matrices, we shall know where and when to employ them. The filling materials, too, must possess constancy of form, and susceptibility to that perfect adaptation which shall prevent the drawing in of moisture by capillary attraction, the result of which would be recurrent decay. An understanding of these characteristics is indispensable to the permanence of filling operations anywhere and everywhere, and by whatever method performed, and when they are thus understood, combined with the advantages afforded in the use of the matrix, the operator will accomplish his best results. The matrix should be used, therefore, for the purpose of simplifying the cavity, and never allowed to lead into the use of a treacherous and questionable material.

The matrix is valuable in all those cavities of extreme decay involving the disto-occlusal, the mesio-occlusal, the bucco-occlusal, the disto-bucco, the mesio-bucco, and the disto-linguo and mesio-linguo occlusal surfaces of molars and bicuspids. In many instances the entire corners may be restored, as is intimated and included in the disto-bucco and mesio-bucco, the disto-linguo- and mesio-linguo-occlusal surfaces. No method yet devised for filling these teeth is so satisfactory or productive of such results as when the matrix is employed, as it aids the adaptation of the material definitely and exactly in position. Its chief advantage is in having brought a cavity of compound and complex nature into simple form, and so contributing to the mastery of the material that perfect adaptation and condensation is secured.

A comparison of results at the cervical margin between fillings made of soft gold and those of the cohesive variety shows in so marked a degree in favor of the soft, even in operations where the matrix has not been used, that when this device is employed it places the standard of excellence of soft-gold work far above that of the cohesive.

With the advantages thus accruing, soft gold in the form of cushions or cylinders may be perfectly adapted at the cervical aspect and as far up the wall as desired, capping over with a slab of cohesive which, when anchored in the occlusal surface, makes a handsome and lasting operation.

Another treatment of these cavities is to place tin cylinders or cushions, which may be made by folding the cylinders upon themselves, and adapt at the cervical margin and up the cervico-occlusal wall to the top of the step D, Fig. 247, completing with the slab of cohesive gold or of amalgam for the remainder of the filling. (See Fig. 251.) The soft gold and the tin are practically the same in adaptation, due to the fact that in their manufacture the molecular arrangement is destroyed and becomes structureless, by which a closer and more perfect adaptation is possible. The matrix enables the operator to take advantage of this important quality; and without thus simplifying the cavity, it would be quite impossible to confine, control, and condense these materials, and secure adequate solidity and adaptation to margins.

The use of the matrix, therefore, not only enables the operator to place soft gold in a satisfactory manner at the points where it serves best, but also cohesive gold where it is best adapted—namely, at enamel margins, and in that portion of the filling where it is most easily and perfectly adapted. Again, cohesive gold is placed in matrix work at that point where it best resists the attrition and stress of chewing, and the lateral wear between the teeth.

Still another treatment of these cavities in connection with the matrix is with amalgam alloy.

Assuming that the same care and pains have been taken with the preparation of the cavity for the amalgam as for the gold, the simplifying of it by the use of the matrix enables the operator to secure greater solidity and correspondingly better adaptation to the walls of the cavity. This material, used in connection with the matrix and cavity lining, places amalgam alloy on a plane not heretofore occupied by it. In the large proportion of cavities occurring in the class under consideration, this practice stands for much in the saving of these teeth.

CAVITY PREPARATION OF THE MAJOR CLASS FOR MATRIX WORK

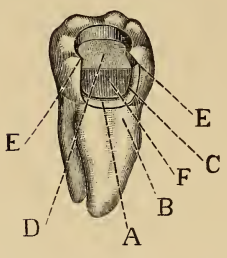
The subject of cavity preparation comes up in connection with the matrix as a matter of first importance.

The form of cavity preparation ordinarily employed in cases of extreme decay of proximal surfaces of molars and bicuspids answers in some measure in matrix work.

In the description of cavity preparation the terms depth, width, and length, as applied to the several walls of the cavity, should be limited,

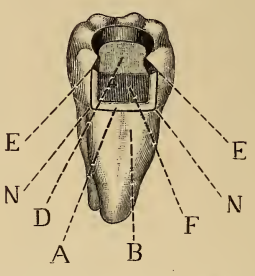
and apply to particular points, and particular points only. For instance, the depth of a cavity should mean from the point of decay toward the pulp, whether penetrating from the occlusal, mesial, distal, buccal, or lingual aspect of the tooth. The width should mean from side to side of the cavity, whether on the occlusal, mesial, distal, buccal, or lingual surface of the tooth. The length, the longest dimension, should mean the greatest length, in whatever direction it extends. The bottom of a cavity should be called the floor, as seen at A and D, Fig. 247. By reference to Figs. 247 and 248 the tooth shown represents a left lower molar, the decay of which penetrates from the mesial surface in the direction of the line leading from F, and we would say that the depth of the cavity seen at A and C was in that direction; and that its width was bucco-lingual, from E to E, or from C on the buccal side to a point opposite on the lingual. This cavity, being a compound one, must have added together for its length, the floor of the step D, the axial wall F, and the floor A. The depth of the lingual and buccal walls is seen at C, and the depth of the floor at A. The axial wall and height of it is seen at F, and the floor of the step at D.

FIG. 247



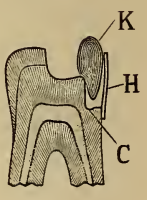
Cavity preparation of a molar for the matrix.

FIG. 248



Cavity preparation, showing square corners.

FIG. 249



Section of molar, showing the introduction of the cushion.

In Fig. 247 is represented the cavity preparation, with which, in connection with the matrix and soft and cohesive gold, the operator is enabled to bring gold work in cavities of this class to a degree of perfection rarely approximated without its aid.

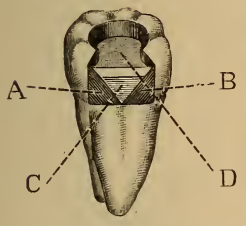
At the cervical margin of Figs. 247 and 248 it will be observed that the floor of this aspect of the cavity, A, and the external wall of the tooth, B, form practically right angles, which is the angle, all things considered, with which to secure the best margins and best results.

Beginning well up on the side wall at C, Fig. 247, passing down and along the base of the cement step and up the opposite wall, is a groove, C, better shown in the sectional cut, Fig. 249, made with a No. 3 or 4 round bur, or Darby-Perry excavator, Nos. 11 and 12, designed as an anchorage for the base of the cervico-occlusal column, marked non-cohesive gold, Fig. 251. In this groove, which should be shallow and

upon the floor surface, A, is condensed the gold. The groove extending up the side wall is not a necessity, though it may be incorporated in the cavity formation when the walls are strong, but that portion of it along the floor should be employed.

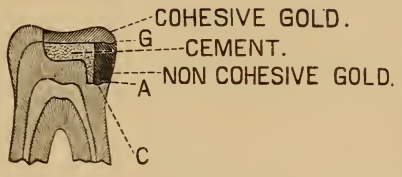
In the instances where the lateral walls are weak and the groove cannot be formed, the occlusal anchorage shown at D, Figs. 247 and 248, should be employed. In the formation of the side-wall edges, E E, Fig. 248, care must be taken to leave them strong enough to prevent fracture under the pressure of the matrix band. These walls should be bevelled on the lines E E, Fig. 248, terminating in an obtuse angle with the external surface of the tooth, if practicable. Less than a right angle should not be depended on, if it can be avoided, as there is danger of fracture.

FIG. 250



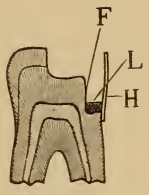
Cavity preparation, showing subdivisions of filling.

FIG. 251



Section showing the plan of a matrix filling.

FIG. 252



Section showing the condensation of cushion *K* of Fig. 249.

In the formation of the cavity in Fig. 247, with the rounded corner C, is seen the preparation suitable for amalgam or other plastic materials in connection with the matrix; and for cushions and cylinders of foil if the cavity approximates the form seen in Fig. 248, and at F and H of Fig. 252. But these corners should be modified as nearly as possible into the form seen at N N, Fig. 248, if the cavity is shallower from A to D, Fig. 248, than from F to H, Fig. 252.

The square corners aid in better locking and binding the foundation subdivisions in the process of building in the filling (see Fig. 250).

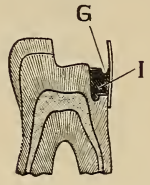
But when the cavity assumes the proportions seen at F to H, Fig. 252, the matter of square corners is not necessary, because when the distance from the top of the step, Fig. 252, to the floor is greater than from F on the axial wall to H on the matrix band, we have a form of cavity in which the cushions and cylinders bind and hold without the aid of square corners.

It should be a rule of practice to put in cement steps whenever the distance from the axial wall to the matrix band is greater than from the top of the step to the floor of the cavity, and bring the form of the cavity as nearly as possible into that shown in Figs. 249, 252, 253, and 255; because, first, it necessitates the use of less metal, whether of gold or tin;

second, it is better when finished, and more quickly filled to the top of the step (Fig. 253); and third, it avoids the formation of the square corners, N N, Fig. 248, extending so deeply toward the pulp as to weaken the walls of the tooth.

In the introduction of the filling into the corners of Fig. 248, the method suggested is to carry in the cushion of soft gold or tin, as the case may be, and place in the corner at A with pluggers, Nos. 257, 258, or 259, Fig. 291, whatever size of these forms shall best suit the case, and partially condense it. In the opposite corner place in the subdivision B, and then the subdivision C. Only this last introduction is carried straight down in the direction of the long axis of the tooth, while the other subdivisions, as seen in Fig. 250, are placed in diagonally and compressed in place. At this juncture hold down with a suitably shaped instrument, No. 174 or 175, Fig 291, on one side and condense the other with the automatic mallet carrying a suitably shaped plugger, No. 18, Fig. 291, until adequately condensed. After this, change instruments

FIG. 253



Section showing cervico-occlusal wall built to top of step. *G*, groove for the grasp of the capping slab.

FIG. 254



Section of pulpless molar before placing in the cement step.

FIG. 255



Section showing the reconstruction of pulpless molar with cement step.

about, and treat the opposite side in a similar manner. If the cushions are proportioned properly to the size of the cavity, two sets of each of these put into subdivisions A, B, and C, Fig. 250, will bring the wall to the top of the step, or nearly so.

Fig. 247 represents the preparation of decay cavities, whether appearing on bicuspids or molars, the outer outline of which appears in Fig. 256 and comes under the head of the major class. All such decays should as nearly as practicable be prepared after the suggestions of Fig. 247.

In the formation of the cavity in Fig. 247, when the tooth is normal and its functions comfortably performed, care must be exercised to avoid too near approach to the pulp, particularly when the cavity is located in bicuspids, in which case we have a shallower zone in which to work than is found in the corresponding parts of molars. In the deeper cavities of bicuspids and molars, zinc phosphate should be used to bring the cavity into simple form, as seen in Figs. 251, 254, and 255.

When these cavities are prepared after the suggestions and illustrations of the figures referred to and embraced by the matrix, not only is less material needed to bring up the cervico-occlusal wall to the top of the step, but additional advantages are gained in that the cavity is simplified, the filling rendered easy of execution, and the character of the work improved.

Oxyphosphate of copper cement, being more adhesive and less a thermal conductor, and possessing more of antiseptic property than the other forms of zinc cements, should be employed wherever practicable for step making. Its inky blackness perhaps is against its use in the anterior teeth, and farther forward than the molars. But it is also less irritant and is harder and stronger than any of the zinc phosphates. So that, in the instances where the cavity penetrates to or beyond the pulp, and compels the formation of a cavity as deep from the matrix band to the axial wall, as is shown in the pulpless tooth, Fig. 254, or as already cited, when the depth of the cavity from F to H, Fig. 252, is greater than the height of the step, the cement should be placed in position to bring the axial wall close enough to the matrix band to form the cavity into the proportions shown in Figs. 249, 252, and 253 when embraced by the matrix.

This class of cavities, when filled with gold, should be filled with soft gold cushions or cylinders to the top of the step D, Figs. 247 and 248, when, after forming the groove shown at G, Figs. 251 and 253, should be completed with cohesive gold and built securely in place. The anchorage, Figs. 247, 248, and 250, at D, indicate what this should be.

The procedure in the introduction of the soft-gold part, or of tin when that is used, in the major class, is seen at K, Fig. 249, and when condensed, at L, Fig. 252. The introduction is in the direction of the long axis of the tooth and not diagonal, as shown in Fig. 250, although the diagonal introduction may be employed in special cases favoring it. The cushions thus introduced, rarely less in size and bulk than a size 3 cylinder, and generally much larger, do not fill up squarely out to their ends or to the lateral walls; and the operator must look to these points, and level them up with small cylinders or their equivalent in cushions.

The final condensing of this column as seen at I, Fig. 253, and before the cohesive part is begun, should be done by holding down the gold at one side of the cavity, while the automatic mallet condenses at the opposite, as suggested in the filling of the cavity of Fig. 248. The student must appreciate the importance of condensing first the soft gold at N, and afterward the cohesive at E, Fig. 248, when that figure is embraced by the matrix. Pluggers Nos. 7 or 8, Fig. 291, of small treading surface, are suitable for doing this part of the work. The cohesive gold should be used in narrow strips when the angle into which it must go is close and sharp.

It is the purpose in engineering construction to secure the greatest

possible strength from the arrangement of material entering into such construction. In the formation, therefore, of the anchorage for the fillings of the major class of the cervico-occlusal cavities, due regard must be given to the proportion of gold and enamel in making the anchorage head in the occlusal surface of fillings of this class.

Just as it is possible to weaken a carriage wheel by having the tenons of the spokes so large as to weaken the hub, it is also possible to have the tenons so small and the hub so strong as from this cause to weaken the wheel. So also with the anchorage of this class of fillings; the neck of gold going into the head of the anchorage may be so small, narrow, and shallow that the stress of chewing will cause it to break at this point. And yet the neck may be widened and deepened so much that the gold becomes stronger than is necessary, and the enamel on either side becomes correspondingly weak, and gives way under stress of mastication.

The problem then is to proportion the neck of gold and the enamel so as to secure the greatest strength.

Assuming the depth of the gold neck to be about its width, the rule of one-third gold in width and two-thirds enamel, one third each side of the gold, answers the requirement.

THE MINOR CLASS

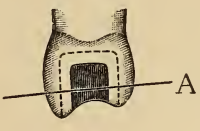
While the principles inculcated by Drs. Webb, Black and others in extension for prevention—extending the cavity margins well away from the contact point of the teeth—hold good in the larger proportion of cases, there are those individual instances presenting when the operator will not

Fig. 256



Bicuspid, showing the major and minor class cavity outline.

Fig. 257



Side view, showing the outline of the major and minor preparation.

Fig. 258



Transaxial section, showing anchorage of the minor class at line *A* of Fig. 257.

be justified in employing extension for prevention. Take, for instance, the highly developed teeth, with perfectly fused enamel through the sulci dividing the cones, lobes, and cusps of the molars and bicuspids, which from the excellence of their quality and the cleanliness of the patient almost entirely prevent caries; it would be unwise and unnecessary under these conditions to extend in preparation the borders of these cavities to the extent taught and endorsed in extension for prevention, and yet so necessary in many of the larger decays denominated the major class.

The preparation of the minor class of decays, represented in the inner outline of Fig. 256, should be formed after the suggestions of Figs. 257, 258, and 259. The student should comprehend the formation of both the major and minor class, as each must be prepared according to the suggestions made.

The preparation, therefore, for the minor class may be enlarged to the proportions shown in the inner outline of Fig. 257, while the outer outline of Figs. 257 and 259 would show the formation of the major class on the same tooth.

Fig. 260 is a sectional cut showing the completed major class of the cervico-occlusal fillings, as adapted to and completed in the bicuspid.

Fig. 258 is a transaxial section at the line A on Fig. 257; and at this point the anchorage for the minor class is seen in Fig. 258. The anchorage can and should be made strong here under the buccal lobes of bicuspids and molars, and similarly at the lingual sides. Above the anchorage, toward the occlusal surface, the cavity should be so modified as to come out on the occlusal surface, as shown in Fig. 259.

Fig. 259



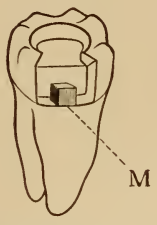
End view, showing outline of major and minor cavity preparation.

Fig. 260



Section showing the completed major class filling on bicuspid.

Fig. 261



M, 2-grain cube of gold, showing relative size to the cavity in which it rests.

The pluggers, Nos. 115 and 116 or 117 and 118, Fig. 291—pairs in two sizes—are invaluable for tacking the cohesive gold into the condensed soft gold. Much of this part of the work must be done by hand pressure; and it is important, in view of this fact, to prepare the gold in narrow strips, which should be annealed with electric heat to insure the strongest cohesion.

In the filling of this class of cavities the matrix should be applied, and soft gold brought up to the anchorage shown in Fig. 258. At this point cohesive gold should be thoroughly condensed into the anchorages, and brought out, finishing the contour of the tooth. Care should be taken to bevel somewhat the occlusal surface of this filling to prevent the too positive impinging of the occluding tooth in the opposite jaw.

The beginning of the cohesive on the condensed soft gold and the fastening of it there, in whatever class of cavities, depends on careful attention to several details: First, the operator must so conduct his operation as to control the saliva perfectly, keeping his work dry. Second,

the matrix must be fixed and rigid in its application. Third, the pluggers should be kept freshly serrated, and of such forms as give direct entrance to and application of them at the point on the work. Fourth, the serrations should be clean and deep. Fifth, the gold should be clean, and freshly annealed. Any of the forms of cohesive gold may be used if the portions carried each time to their destination are small, clean, and annealed. Small cohesive gold cylinders, Nos. $\frac{1}{4}$ and $\frac{1}{2}$, are easily used for this work, and the smaller ones should not only be employed to begin with, when this form is used, but as far as practicable throughout. The strips or ribbons, however, of cohesive gold when freshly annealed, and with all other conditions above enumerated complied with, give best results. The ribbon is tacked or pricked into the soft gold by interdigitation, and the union made with this or any preparation of cohesive gold while not strong, is enough so to enable the operator to reach his anchorage points, where he may thoroughly secure the work.

In making matrix fillings, if the matrix employed is of the band or loop variety and has no separating feature, in order to secure contour, and to have the fillings finished in the original form of the tooth, the teeth, if two are together, should have the cavities previously packed with cotton, long enough to produce mobility of them, so that they may more easily yield apart. This then gives opportunity to push the teeth apart still farther, especially with those matrices provided with the separating feature, and so to gain room in which to shape the matrix band and to reproduce the contour of the tooth.

PREPARATION OF GOLD FOR MATRIX WORK

In the soft-gold part of matrix work the form of the gold to be employed is important to be understood. Large cylinders and cushions in comparison with those ordinarily used in cavities of given size are not only more safely and perfectly adapted, but more quickly done. This results from doubling and partly compressing the cushions, which, being further susceptible of compression, are still large enough to squeeze in place and bind as they are compressed.

In placing cushions into the bottom of large cervico-occlusal cavities of molars and bicuspids embraced by the matrix, it is important to start with those of sufficient size and density to bind as they are condensed, but it is not to be understood that the first such piece introduced must be fully condensed before other similar pieces are added. If this practice were followed, notwithstanding the fact that the first piece introduced binds as it is condensed, this is so only to a certain point of the condensation. Beyond this, if we continue it, especially to that density which may be obtained against the resistance the tooth affords, it loosens, will tilt and rock, and is worthless. But if after placing in one cushion,

which the operator learns to proportion to the size of the cavity, and partially condensing it, he introduces another and carries the condensation to the point of the first, and still another, he may then mallet until the mass will yield no more; and the wall of soft gold thus built will be steady, well adapted, moisture proof, and impervious to leaking by capillary force. This comes of the fact that when three or more cushions or cylinders are carried down as described, the bearing up and down the axial and matrix walls is sufficient to insure binding and steadiness.

In the illustration, Fig. 249, will be observed at K a gold cushion entering the cavity between the axial wall F and the matrix band H. The cushion is made of one-half of the gold twist shown at Fig. 262, and contains two grains of gold by weight. This cushion, when condensed to its ultimate density, as by melting and hammering, is represented in cube form and exact size at M, Fig. 261.

FIG. 262



Leaf of No. 4 gold foil, twisted ready for formation into cushions.

A No. 4 gold cylinder, as made by the manufacturer, one-fourth of an inch long, contains one grain of gold by weight, and when this is condensed into cubic form it is one-half the bulk of the cube shown at M, Fig. 261. It transpires then that the large loosely made No. 4 cylinders of one grain weight are more difficult of satisfactory adaptation than those which contain the two or more grains, because the large loose ones lack the bulk and substance which is necessary to cause them to bind and fasten in condensing.

It will be seen further, by comparison of the 2-grain cube M, Fig. 261, with the proportions of the cavity in which it rests, that it reaches hardly half across the cavity, bucco-lingually, and that if this cube were elongated so as to reach across the cavity, its bearing against the axial wall and the matrix band would be lowered at least one-half, and there would not be sufficient bearing up and down these walls to hold the gold fixedly in place. This then demonstrates the difficulty of adapting gold or tin foil at such points with cylinders or cushions containing less than enough material to bind and hold the mass in place in the process of condensing. And if this be true, as is illustrated in Fig. 261, it is seen that the size 4 cylinder, containing only one grain, would be still more difficult to control, because it lacks in greater degree the bulk and substance sufficient to give the bearing up and down the walls necessary to the binding and fastening in the process of condensing. Neither will the cylinders or cushions containing two grains or more in very large cavities bear complete condensing, before adding other pieces without loosening, for the reasons already given. In exceptionally large cavities of the major class, a sheet of No. 4 foil may be formed into a single cushion,

and introduced to advantage. Such a cushion containing four grains would not build higher than is necessary to bind, even if it were formed into a rectangular parallelopiped—two cubes side by side, and extending from one lateral wall to the other.

The successful making of fillings with either gold or tin is not so much a question of securing the ultimate density of these materials, as that of securing adaptation of them to the walls of the cavity in such manner as shall prevent leakage beneath, in, and around the filling. This result may be obtained with a compression or condensation of much less density than is shown in the melting of them, or as is obtainable against the resistance which the tooth offers.

FORMATION OF CUSHIONS FROM FOIL

The cushion of either gold or tin, rather than the cylinder, is a better preparation for matrix work, even when it is made from cylinders compressed or doubled upon themselves, because the cushion, made of foil, while soft enough to be adapted to the irregularities of the cavity, contains from twice to four times the amount of material which the loose cylinders do, and because of this fact, in connection with proper handling and cavity formation, they are more easily secured in place.

The student should appreciate the fact that until he succeeds in laying the foundation of soft-gold work in a manner to prevent its moving or shifting position in the process of condensing, he will have failed to secure the results within his reach. The employment of the cushion, therefore, rather than the cylinder, is urged as the best means to this end.

The formation of cushions from the foil is as follows: Take a full leaf of No. 4 soft gold foil, and with clean hands crimple and wrinkle it. Straighten this out, but leave the sheet undulated, when it should be loosely folded three to four times upon itself and loosely twisted. The twist thus made should be cut into from three to five pieces, Fig. 262, depending on the size of the cavity to be filled. The large cavities, such as are seen in the proximal surfaces of molars, Figs. 247 and 248, will take a cushion made from the longer section of the twist shown in Fig. 262, which may represent one-half or more of the sheet of No. 4 foil; while cavities of the proportions shown in Fig. 257 will take one-fourth or less. Smaller proximal cavities in the incisors will take from one-fifth to one-third of a half-sheet prepared after the manner of Fig. 262. The cushions prepared after these suggestions, when used for the large cavities of the molars and bicuspids, should somewhat resemble the illustration in Fig. 263. The preparation thus made is more desirable than the cylinders made of soft foil, because it is more easily manipulated and with better results, and because the student learning to do

this secures to himself a resource which enables him to prepare his cushions for all sizes of cavities, and is never at a loss for what is wanted when foil is to be had.

But when this class of work is to be done with tin foil, the cylinders, compressed or doubled, will serve best, since it is difficult to obtain a foil of tin light enough and soft enough to make desirable cushions.

Fig. 263



Cushion formed from twisted leaf of Fig. 262, or from partially compressed cylinders.

Tin foil in cushions, made by doubling the cylinders upon themselves for the foundation portion of cervico-occlusal fillings, in connection with the matrix, and under the finishing slab of cohesive gold, works even more kindly, and adapts more easily than cushions made from soft gold foil; and if its use here is not forbidden by electrolysis, it is to be given first place as a tooth preserver at the cervical margins, and as a non-conductor of the thermal changes to the pulp. Tin foil and soft gold foil laid together, and the two formed into cushions after the suggestions already made, may be used with results quite as beneficial for preservation of the margins embraced by the matrix as when gold or tin alone is used, with the advantage of avoiding the danger of electrolysis of tin under gold.

FINISHING THE FILLING

No part of the work of making gold fillings, such as are included in the major class particularly, is more laborious than the finishing of them. Yet when the matrix has been properly adapted to the teeth, the finishing of the cohesive gold part may be lessened to the minimum.

The more rapid and satisfactory finishing of the work following the use of the matrix is no small part of the advantage of this device, since the matrix gives not only the form of the wall which it embraces, but more than any other method yet devised saves filling material. This comes of the fact than when it is properly adjusted the cavity is converted into a mould so nearly the shape of the filling to be, that when it has been made very little work remains to be done in polishing.

The first step toward polishing after removing the matrix is to go around the borders of the soft-gold portion of the filling with a blade burnisher, which should be kept highly polished and clean. In this operation the object should be to compress as much as possible by hand pressure the soft-gold portion that may have bulged under the malleting. After this the Rhein trimmers, Nos. 31 and 32, should go over the

borders, and should be held so that the blade shall rest equally on the filling and the adjacent external surface of the tooth.

At this point, if the operation is between molars or bicuspids, the Perry separator is valuable, and should be placed so as to have the beaks impinge above the margin of the filling, and should be made to open the teeth only enough to pass in the thinnest strips and sandpaper disks. Care and skill are required in the handling of disks to avoid grinding away the contour of the filling, but the disk can be so held as to prevent this.

The author finds, in removing the overhanging corners of the cohesive portion of these fillings, that the use of a stiff five-eighths inch garnet disk, held only to the corners and not permitted to pass in between the teeth, answers better than any form of corundum or carborundum wheels.

After thus carefully shaping the cap or slab of cohesive gold at the contact points, and rounding them as the case permits and requires, flint strips and the "regular" grit, followed with the "fine" cuttlefish disk, completes the polish.

The occlusal surface of cohesive gold is easily shaped with corundum wheels and polished with the cuttlefish disk, when these can be made to apply, or with leather wheels carrying pumice.

There is no essential difference in polishing the major and minor class of these fillings, except in the extent of the work.

FORMS OF MATRICES FOR MOLARS AND BICUSPIDS

A presentation of all the devices known as matrices is not the purpose of this chapter, but only of those whose efficiency commends them.

Fig. 264 represents the set of matrices devised by Dr. Louis Jack. This set of matrices is provided with concave surfaces for contouring the teeth, which indicates the high ideal of the originator of the device. They are made thick and heavy at the base of the lateral edges, which aids in steadying them between the teeth, and they are provided with slotted edges, which engage a special pliers to insert and remove.

Fig. 265 shows a set of loop matrices, which at times, and with teeth of slight constriction at the neck, answer well; but, like all of the loop variety, they require space at both sides of the tooth to admit of adjustment.

Fig. 266 exhibits a set of matrices devised by Dr. Truman W. Brophy, which, with the flexibility of the thin steel bands and under the action of the screw, may be made to aid the operator most acceptably.

The band is not unlike the loop in the matter of passing between the teeth, and the teeth must yield apart to admit it. Still, with the thinness of the bands in this set, there is no difficulty in this particular.

This form of matrix, however, is unsteady and difficult to fix rigidly on very short crowns, and particularly on those of decided conicality.

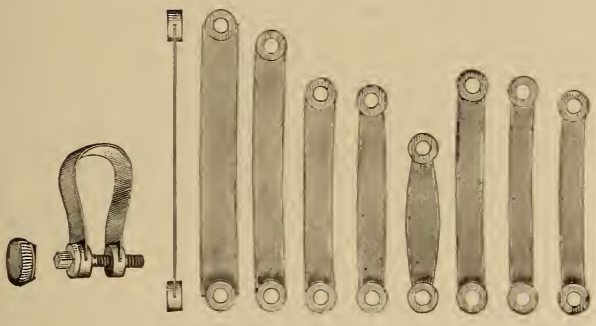
Fig. 267 exhibits an improved loop matrix devised by Dr. S. H. Guilford, in which the lip feature is added for the purpose of having the band to catch below the cavity, without the necessity of forcing the band

Fig. 264



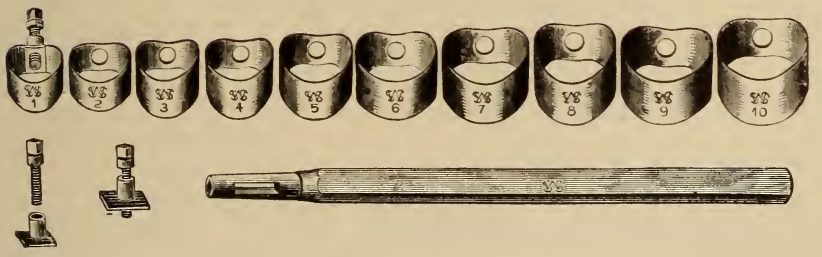
The matrices of Dr. Louis Jack.

Fig. 265



Loop matrices.

Fig. 266



Brophy's band matrices.

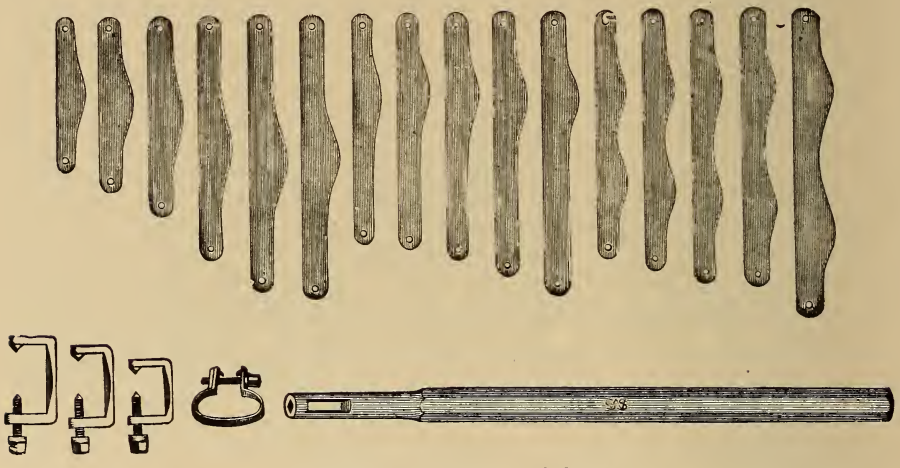
elsewhere around the tooth into the gum. This device, made in several lengths of bands, although tedious to adjust, from the fact that three pieces must be handled, is otherwise valuable and serviceable.

Fig. 268 illustrates Dr. W. A. Woodward's screw matrices. This form of matrix has valuable features in that the thin metallic ribbon constituting the matrix wall may be made as thin as No. 36 to 38 gauge, and yet possesses adequate tensile strength. The device is also valuable because in its use only one thickness of the ribbon need be carried

between the teeth. Again, it has the separating feature, which makes it additionally desirable, as this forces apart the teeth to start with, and the separation is continued as the operation proceeds, or as the exigency of the case demands.

Fig. 269 shows illustrations of Dr. E. B. Lodge's matrix bands, tension screws, and wrench. Those marked A are adapted to bicuspids and molars of usual form, while those marked B are adapted to the same class of teeth, but of constricted necks and more pronounced bell-shaped crowns. C and D of this illustration show two forms of tension screws, and F and E the wrench for operating the screw D. Fig. 270 shows the Lodge device adjusted to the teeth.

FIG. 267



Guilford's band matrices and clamps.

FIG. 268



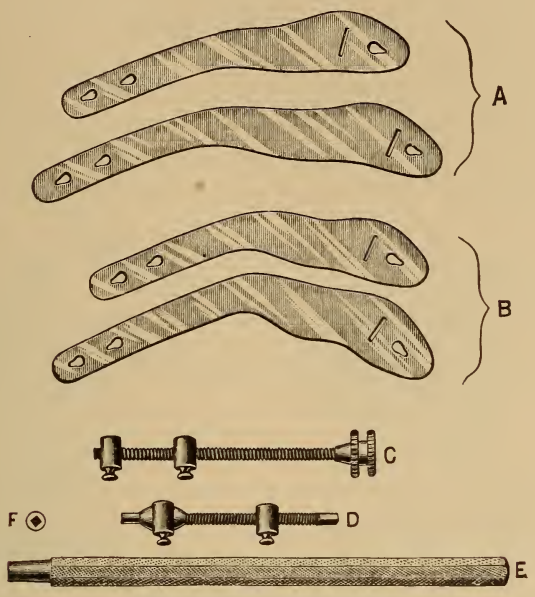
Woodward's screw matrices.

The bands of the Lodge matrix are made of German silver, and are provided with two eyelets in each, giving ample range of adjustment.

Figs. 271 and 272 show a form of matrix suggested by Dr. A. C. Hewett, which for simplicity and efficiency meets a constantly occurring want. In the instances where the matrix is employed between the teeth and it is braced by an adjacent tooth, and where no straining apart of the teeth is required, this device is admissible. But it should be braced with a wedge, ordinarily at the cervical edge.

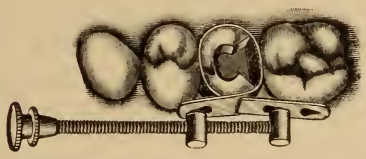
Fig. 273 is a form of matrix which has been used by the author in extensive cavities occurring on the buccal surfaces of lower molars.

Fig. 269



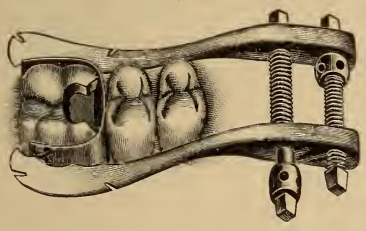
Lodge's system of loop matrices.

Fig. 270



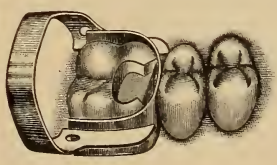
The Lodge matrix in position on the teeth.

Fig. 271



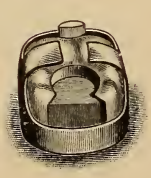
The Hewett matrix held in position with the Parmly Brown clamp.

Fig. 272



The Hewett matrix held in position with the ordinary rubber-dam clamp.

Fig. 273



The band matrix used in extensive buccal surface cavities on lower molars.

The band which must be fitted to each case is made from No. 35 to 36 gauge German silver, and so cut that the projecting arms turned down

on the occlusal surface of the tooth prevent it from carrying down with the wedge as the device is tightened. In the instances where the cavity extends beneath the gum the band can be provided with a lip to catch below the buccal margin. The dam can rarely be employed in these operations, but fortunately it is not necessary for the first part of this operation.

When the lingual and buccal sides of these teeth are provided with absorbent-cotton rolls, and especially when the saliva ejector is employed, the cavity may easily be filled to the top of the band with soft gold or tin, as suggested elsewhere in this chapter, before moisture shall interfere.

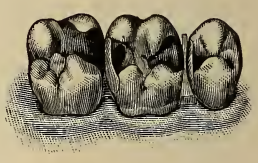
If the capping for this filling shall be of amalgam, it may be finished within the time that the absorbents protect. If the purpose is to finish with gold, the dam should at this juncture be placed over the band and tooth after the soft-gold part is brought to the top of the band, and the remainder of the work finished with cohesive gold.

FIG. 274



The Hodson contour slip matrices.

FIG. 275



The Hodson matrix in position between the teeth.

Fig. 274 represents the contour slip matrices devised by Dr. J. F. P. Hodson. The device is a most meritorious one, with which the contour of molars and bicuspids can be fully restored, but can only be used between the teeth. Fig. 274 gives two views of the matrix ready to be slipped in place.

These matrices are made preferably of thin annealed steel plate, forged or swaged on a leaden slab with an oval-end punch, giving them whatever of concavity the case may require; they are then slipped in place, which causes the teeth to yield apart. The gingival end of the device should be braced against the adjacent tooth with an orange-wood wedge until after the filling is inserted.

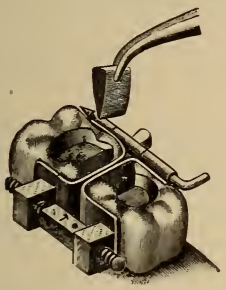
The Hodson device is better adapted to amalgam work than gold, because it does not possess the rigid fixedness in sufficient degree to remain securely in place for extensive gold operations.

If the filling material used is a plastic the device is left in place over night or longer, allowing the filling to set under pressure, which may be done readily, as the device shown in Fig. 275 is in no wise uncomfortable or troublesome to the wearer.

When the adjustment of the matrix is properly made, it is unnecessary in most instances, particularly in the upper jaw, to use the dam.

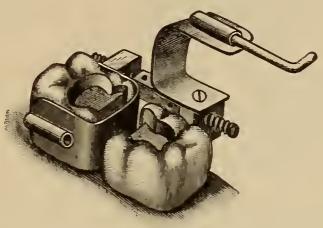
Fig. 276 represents the contour matrix as devised by the author of this chapter. This device, which is of duplex form, is only used between the teeth, and acts in the three-fold capacity of matrix, separator, and rubber-dam clamp. The device is shown in position between two molars, the cavities of which have been prepared after the suggestions of Figs. 247, 248, and 249, and the manner of introducing the cushion. With this form of matrix the teeth may be drawn apart as with the separator, and the fillings given the contour the teeth originally possessed.

Fig. 276



The Crenshaw contour matrix in position between molars.

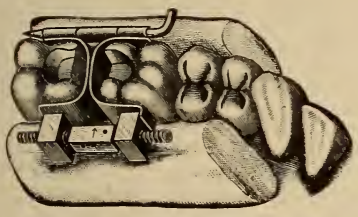
Fig. 277



The contour matrix with one band turned out for removal.

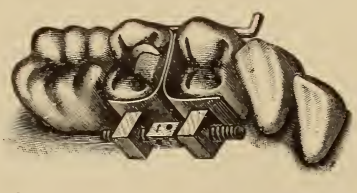
Fig. 277 shows the method of removing the matrix, as may be done when amalgam is used without lifting or unseating the filling. To do this the pin is withdrawn and the band embracing the unfilled tooth is turned out on the tension screw as a pivot. After this the band embracing the filled tooth is lifted away from it, when the matrix may be removed from between the teeth. In amalgam work with this device only one tooth should be filled at a sitting, and after this filling has crystallized and become fixed in the tooth the second one should be made.

Fig. 278



The contour matrix holding absorbent cotton in position.

Fig. 279

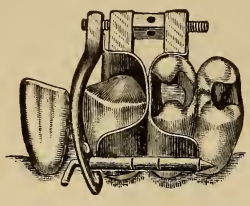


The contour matrix in position between bicuspids.

Fig. 278 shows how the operator may protect his work without the dam in the lower jaw by placing absorbent-cotton rolls on each side of the teeth, and how these are held in place by the matrix. The employment of the cotton rolls gives time in which to insert amalgam and other plastic fillings before the rolls become saturated with saliva. In the same

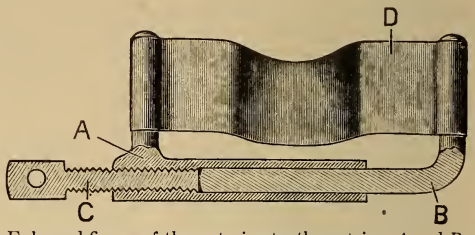
manner the cervico-occlusal columns of these fillings may be made of gold or tin cushions to the top of the step with the aid of the rolls and the saliva ejector, when the matrix should be removed, the dam put over the teeth, the matrix reapplied, and the operation finished with cohesive gold.

FIG. 280



The contour matrix in position between canine and first bicuspid, with bow brace attached.

FIG. 281



Enlarged figure of the anterior teeth matrix: *A* and *B*, arms; *C*, projection screw; *D*, metallic ribbon.

Fig. 279 shows the application of the short-bar matrix as adapted to bicuspids and between canines and first bicuspids. The bicuspid device is better adapted for use between molar and bicuspid than the molar one, although the latter may be employed at these points.

Fig. 280 shows the contour matrix in position between a canine and first bicuspid, in connection with the bow brace, which prevents the matrix slipping from between the teeth, as it is inclined to do on account of the bevel of the lingual side of the canine.

MATRIX FOR THE ANTERIOR TEETH

In the effort to improve gold work in the proximal cavities of the anterior teeth by a method which practically does away with cohesive gold, the author offers the anterior teeth device.

Fig. 281 shows the device enlarged, as it appears before being placed in position about the teeth, and with the lower part shown in section. The arms at A and B project through the loops formed on the ends of the metallic ribbon D, the thickness of which is $\frac{4}{1000}$ of an inch, and which may be passed between teeth of rigid contact. The parts A and B are separable, and when the tension screw C is turned in, the arm B is extended, which puts the ribbon D under tension.

Fig. 282 shows a lingual view of four incisors with the matrix ribbon in position before it has been adapted at the incisal edge. Fig. 283 shows the ribbon crimped and soldered, which adapts it closely to the tooth at the incisal edge, and to the surface of the tooth beneath the ribbon.

Fig. 284 presents a labial view with the device in position, and shows how cavities which extend through and open on the lingual face of the tooth may be floored and brought into simple form.

Fig. 285 shows a means of taking up slack in the ribbon, if this should become necessary, by slipping the slitted arm astride of the ribbon, as shown in this figure. By this means, if at any time the tension screw should be run in to its limit, additional tension can be obtained without removing the ribbon.

Fig. 282



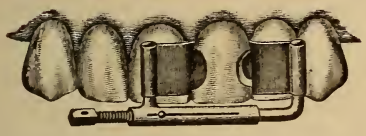
The metallic ribbon in position before crimping.

Fig. 283



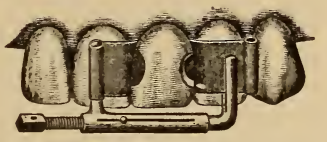
The metallic ribbon adapted to tooth after crimping.

Fig. 284



The holder applied for tensioning the ribbon.

Fig. 285



The holder applied for taking up slack in the ribbon.

Fig. 286



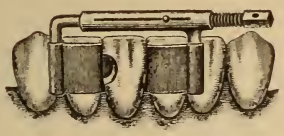
Application of the ribbon pressing the left central forward.

Fig. 287



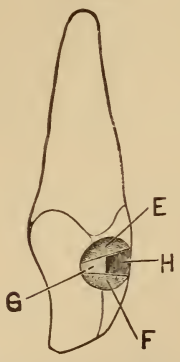
Application of the metallic ribbon between the anterior lower teeth.

Fig. 288



Application of the holder pressing the lower right central forward.

Fig. 289



E, cervical, *F*, incisal, *G*, lingual, *H*, labial subdivision of proximal incisor filling.

Fig. 286 is a view showing the cutting edge of the teeth and the crimp of the metallic ribbon.

Fig. 287 is an application of the ribbon to the lower incisors. It must ordinarily be placed between the teeth before applying the holder. Fig. 288 shows the holder in position.

FILLING PROXIMAL CAVITIES WITH COHESIVE AND NON-COHESIVE GOLD WITH ANTERIOR TEETH MATRIX

Fig. 289 shows a proximal cavity in a central incisor three-fourths filled by the aid of the matrix, after which the matrix is removed. The subdivisions of the filling, lettered E, F, and G, are made of soft gold, leaving the space marked H to be filled with cohesive gold. The procedure which best accomplishes this is as follows: If the cavity be a large one, take a No. 3 or 4 soft-gold cylinder and double it upon itself and again crosswise, making a firm cushion. Let this cushion be large enough to squeeze into place. Take a foot-shaped plugger with light serrations, Nos. 257, 258, or 259, Fig. 291—whatever size of this form best suits the case—and press this first cushion into the undercuts of the cavity at E. After settling it by hand pressure, take a suitable foot-shaped plugger, No. 257 or 258 answers well, in the automatic mallet, and, while holding down at the lingual side of the cushion, mallet the other, after which change the instruments about, and mallet the labial side. After this is done, treat the opposite end of the cavity at F in the same way, only the cushion going into this subdivision may occasionally have to be drawn into place with the throat of the instrument. When the F subdivision is condensed, use a No. 2 cylinder folded once upon itself, and introduce end-wise at G, which when condensed keys E and F in place. If the cavity be a large one it will require two of the No. 2 cylinders, and in some cases three, to bring this part of the filling to the centre of the cavity, which is necessary in order to securely brace E and F in place.

The author cautions against using small soft cylinders with which to make a key-block, because when condensed they do not build up high enough to obtain the necessary lateral bearing against blocks E and F to hold firmly in place. Neither should cohesive gold in any form be used here.

It will be observed from the lines of the cavity division in Fig. 289 that the cavity is to be filled from the labial side, and that it extends through into the lingual face of the tooth, also that the matrix ribbon, which has been removed to show the plan of the filling, envelops and embraces the tooth in such manner as to floor the lingual portion of the cavity, as may be seen in Figs. 284, 285, 287, and 288.

The action of the device not only moves the tooth forward to be filled as seen in Fig. 286, so that it may be got at easily, but transforms a difficult cavity into one of easy, simple form.

In the instances where the opening of the cavity is toward the lingual aspect with a labial wall to be preserved, the device operates with as much favor in filling from the lingual as from the labial aspect—see Figs. 283 and 286. In these figures the action of the device will be

seen to move forward the left central and depress the right central and left lateral.

When the filling is made from the lingual aspect, the lines of the subdivisions of the filling, Fig. 289, would be reversed, and the key-block H would be placed in the position of G.

PLUGGERS FOR MATRIX WORK

The point of a plugger is not all of its efficiency. The handle may materially enhance or handicap its performance, and the average student, unless guided in the selection of points and handles, is apt to get together in the selection of excavators and pluggers an incongruous combination, much of which will prove unsuited and unfitted for anything he is called on to do.

Some of the forms of pluggers here suggested for matrix work may be found in the student's case. All included in the list of Fig. 291 are regarded as cohesive gold instruments, but several of these forms are ill adapted to that work and well adapted for soft gold. Many of the forms of instruments included in sets of soft gold pluggers cannot be utilized in the execution of the soft-gold part of the matrix fillings set forth in this chapter; and to assist the student in knowing which instruments shall be used to manipulate the cohesive, and which the soft, and the handles best suited to them, are pointed out and explanation of their uses made.

The Handles Adapted to the Pluggers.[1]—Nos. 7, 8, 10, 18, 115, 116, 117, 118, 207, and 208 should be placed in cone-socket handles Nos. 4 or 5, Fig. 290, according as the shank of the plugger point is small or large. These handles can be used for hand pressure, but are designed especially for the hand mallet.

Nos. 174, 175, 248, and 250 should be placed in the cone-socket handles Nos. 2 or 3, Fig. 290, according as the shank of the plugger point is small or large.

Nos. 257, 258, and 259 should be placed in the rubber handles No. 10 or 10A, Fig. 290, according as the shank of the plugger point is small or large.

The Uses of the Several Pluggers.—Nos. 7, 8, 115, 116, 117, 118, and 207, Fig. 291, are for cohesive gold, and may be made to answer the needs of this work in connection with matrix fillings.

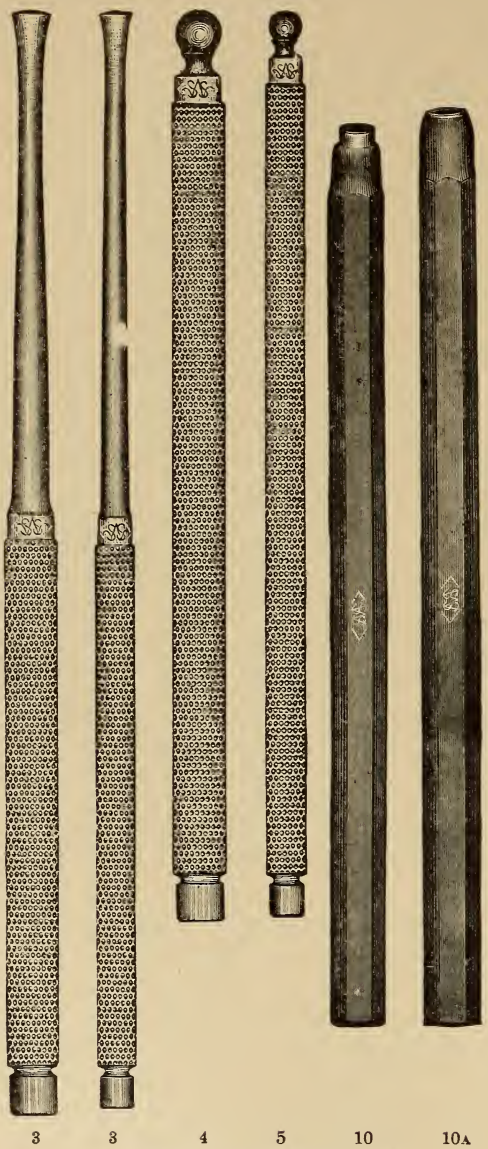
No. 60 Parmly Brown plugger point, for cohesive gold, is of universal application, and is best used in the electric or the engine mallet.

Nos. 174 and 175, Fig. 291, are assistant pluggers, used to hold down when malleting, and may be used for packing cushions in the cervico-occlusal column of molar and bicuspid matrix fillings.

[1] The handles, pluggers, and numbers of same are taken from the revised lists of the S. S. White Dental Manufacturing Company.

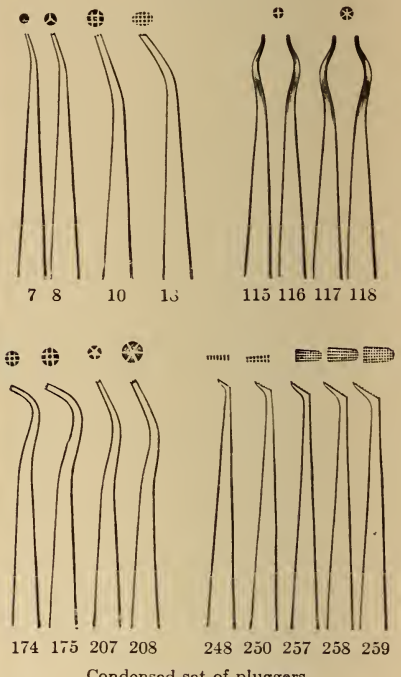
Nos. 248 and 250, Fig. 291, are for soft gold, and used for placing and compressing the cushions into the subdivisions E and F, Fig. 289, of the smaller class of approximal incisor cavities.

FIG. 290



Handles for cone-socket points.

FIG. 291



Condensed set of pluggers.

Nos. 257, 258, and 259, Fig. 291, are for compressing the cushions into subdivisions E and F, Fig. 289, of the larger class of approximal incisor cavities. The square corners at the toe of these forms should be rounded off.

Nos. 10, 18, 208, 248, and 250, Fig. 291, are for settling and malleting soft-gold cushions in the cervico-occlusal column of molars and bicuspids (see Figs. 249, 252, and 253), and for carrying down and malleting the subdivision G, Fig. 289, and fillings of this class.

A MATRIX AUXILIARY

Dr. Alfred P. Lee, of Philadelphia, has devised a simple and practicable method of overcoming the difficulty often experienced in adapting the matrix to a proximo-occlusal cavity when the cervical portion of the missing wall presents a concave surface, due to the tendency of the roots to bifurcate.

By the use of sheet copper, not more than $\frac{5}{1000}$ of an inch in thickness, in conjunction with the Ivory or similar matrix, an appliance is made which when removed after the filling has been inserted will be found to have kept the filling the desired shape, leaving no overhanging portions at the cervix to trim away.

FIG. 292



Transverse section of tooth at a point near cervical border of cavity. Outer line showing copper matrix in position. Dotted line represents degree of contour supplied with hard wax or solder.

FIG. 293



Both matrices in position on tooth crown.

FIG. 294



Shows copper plate with cervical depression filled with soft solder and applied to cavity before adjustment of outer matrix.

A piece of thoroughly annealed copper plate, large enough to cover the proximal portion of the cavity and extend, say one-eighth of an inch beyond the buccal and lingual margins, is pressed with cotton or bibulous paper pellets to conform to the concave root periphery at the cervix. The copper is then carefully removed and, if the cavity be for amalgam, the depression in the copper representing the cervical concavity is filled with hard wax until a convexity is obtained; the copper plate is then placed in position, and around it a steel matrix is adjusted, and when fully tightened the free edge of the copper is burnished against the steel.

When gold is to be inserted it is necessary to use something more stable than the hard wax, therefore the concave surface at the cervical margin of the copper plate is touched with zinc chlorid, and over the alcohol or Bunsen flame soft solder is flowed into the depression. Any surplus may be trimmed off with a disk.

CHAPTER XI

PLASTICS

By MARCUS L. WARD, D.D.Sc.

NATURE OF AMALGAM

An amalgam is a combination of two or more metals, one of which is mercury, and may be either a liquid, solid, or semisolid. The term amalgam is derived from the Greek *malagma*, from *mallasso*, to soften, the presence of mercury lowering the melting point of such a mixture.

The term "metal" indicates a certain number of chemical elements which in the present state of chemical science are undecomposable and possess certain well-defined characters in common, such as opacity, luster, conductivity, high specific gravity, and plasticity or capability of being drawn, squeezed, or hammered without loss of continuity.

Comparatively few of the metals possess characters such as render them suitable to be employed alone by manufacturers, although there are many applications for most of them when two or more are caused permanently to unite. The compound thus formed by the union of two or more metals is termed an alloy. The word alloy is believed to be derived from the French *aloi* (the metal of the standard coin), a contraction of *à la loi* (according to the law). An amalgam, then, represents that class of alloys which contain mercury. The agencies by which the union of metals is affected are heat, electrodeposition, pressure at ordinary temperatures, and by dissolving one or more metals which exist in a solid state at ordinary temperatures in a metal which exists in a liquid state at ordinary temperature.

Practically all alloys, except dental amalgam alloys, are formed through the agency of heat, but certain soft metals, such as lead, tin, bismuth, cadmium, etc., have been shown by Professor Spring, of Liege, to form true alloys under pressure and absence of heat. This process, however, has not as yet found application much beyond the laboratories, where it is used to demonstrate that there is actual union between the particles of different metals in the cold when they are brought into intimate contact. Certain alloys, such as gold and copper, or copper and zinc, may be prepared by electrodeposition. Several alloys are prepared by this method on a large scale.

The utility of dental amalgam alloys depends largely upon the property which mercury has of dissolving most other metals to the point of saturation, forming alloys which, when allowed to stand for some time, harden

or set. This hardening or setting process is probably due to the formation of a chemical compound between the mercury and one or more of the metals used in combination with it. The mass thus formed of metal or alloy in combination with mercury cannot be regarded, however, as a true amalgam, for Matthiessen has pointed out that such a mixture may be either a chemical compound, a solidified solution of one metal in another, a mechanical mixture, or a solidified solution or mixture of all three.

There are some phenomena, such as change in volume, change in strength, and evolution of heat, that lead to the belief that definite compounds do exist in definite proportions by weight. Most of the metals used to form the alloy which is combined with mercury to form an amalgam are capable of existing in a state of chemical combination, although they are subject to Matthiessen's classification, and are usually united by feeble affinities, for it is necessary, in order to produce energetic union, that the constituents exhibit much dissimilarity in properties. There is little doubt that these metals do unite in definite proportions, although it is difficult to obtain them as such, since the compounds thus formed dissolve in all proportions in the melted metals from which they do not differ very widely in their melting points. For these reasons it has been questioned whether not only amalgams, but any alloy were a true chemical compound.

Definite compounds have been proved to exist, however, in both the native and artificial state. Hiorns gives a good illustration of a chemical compound between two metals in the alloy of copper and tin which may be represented by the formula $SnCu_2$, containing 38.4 parts of tin and 61.6 parts of copper.[1] A well-known native chemical compound of two metals is represented by silver and mercury, which are found crystallized together in the following porportions: (Ag_2Hg_2 or Ag_2Hg_6) and (Ag_2Hg_6).

Under the term solution of one metal in another, we understand one like ether and alcohol, or any two substances which may be mixed in all proportions and will not separate into layers by standing. Solidified solution would indicate the solidification of a perfectly homogeneous diffusion of one body in another and has been represented by glass, which is formed in the liquid state at a high temperature and solidifies on cooling without separation of the different silicates. Hiorns quotes Mendeleef as saying that solutions are fluid, unstable, definite chemical compounds in a state of dissociation, and that of such a kind are most metallic alloys. They have been considered in the *Journal of the Chemical Society* as solidified solutions of metals which contain definite compounds in excess of one of the constituent metals. The subject of solution apparently has a most important application in the production of dental amalgams.

In the same manner that water dissolves saline substances, alcohol dissolves resins, ether dissolves fats, etc., mercury dissolves most metals. A very interesting phenomenon to observe in this connection is the manner

[1] Hiorns, Mixed Metals or Metallic Alloys.

in which most solvents act upon solids (Hiorns). As a rule, the dissolving power of each liquid is confined to a certain class of solids. It is also a general rule that the solubility of a body in any medium depends on a similarity in the constitution of the body and the solvent.

When a liquid has dissolved all of a solid that it is capable of retaining at a given temperature, it is said to have become saturated; but even if it be saturated with one solid it may yet take up another, and oftentimes the solvent power is thereby increased.

A general survey of the literature reveals a lack of knowledge of the peculiarities of solutions, and appears to explain largely why so much importance has been attached to the kind of receptacle to be used for mixing alloys with mercury, and the manner of incorporating them.

It appears important that the subjects of crystallization and diffusion should be considered in connection with the formation of dental amalgams, since they are both closely allied with solutions. The placing into solution in mercury of metals or alloys, the subsequent setting (crystallization) of the mass, and a final complete diffusion of these constituents seems to be controlled by the same agencies as are other chemical phenomena. External heat, for example, influences these phenomena a great deal, it being considered that a rise in temperature of 10° C. will double the velocity of 75 per cent. of all chemical reactions.

The conversion of chemical energy into heat may also influence these phenomena. The condition of contact between the mercury and the metal or alloy upon which it is reacting will likewise have its influence upon the above phenomena. The internal movements of the component particles of the mass may facilitate diffusion, solution, and chemical change. In fact, about the only difference that appears between dental amalgams and a majority of chemical compounds is that the metals are united by very feeble affinities, and there exists a great tendency for the amalgam to possess the properties of its constituents. There are some cases where a combination is totally different from either constituent, but the general effect is for each constituent metal to maintain its identity.

The advantage of alloying metals together seems to be to assemble in one compound a number of properties which could not be found in any one element. Through the work of such men as Flagg and Black, silver, tin, copper, zinc, and occasionally gold in small quantities have been found to possess more desirable and less undesirable properties than any other equal number of metals. Since the work of Dr. Black[1] two new but distinct classes of alloy have appeared as the principal products of nearly all leading manufacturers. One of them contains from 65 to 68 per cent. of silver, 26 to 28 per cent. of tin, 3 to 4.5 per cent. of copper, and 1 to 2.5 per cent. of zinc. The other contains from 43 to 48 per cent. of silver, 48 to 58 per cent. of tin, and 1 to 2 per cent. of zinc.

[1] See Dental Cosmos, vols. xxxvii and xxxviii.

The first class is known as high percentage silver alloys, quick setting alloys, and Black's alloys, the three names being synonymous. The second class is known as low percentage silver alloys, slow setting alloys, and plastic alloys. Both classes seem to have grown out of Black's work, the latter class undoubtedly with his disapproval.

EXHIBIT, COMPOSITION, AND PHYSICAL PROPERTIES OF UNMODIFIED SILVER-TIN ALLOYS.

Formulæ.		How	Per cent.	Shrink-	Expan-		Crushing
Silver.	Tin.	prepared.	of mercury.	age.	sion.	Flow.	stress.
40	60	Fresh-cut	45.78	6	7	40.15	178
40	60	Annealed	34.14	9	3	44.60	186
45	55	Fresh-cut	49.52	4	8	25.46	188
45	55	Annealed	32.13	7–11	1	28.57	222
50	50	Fresh-cut	51.18	2	2–4	22.16	232
50	50	Annealed	37.58	10–17	0–1	21.03	245
55	45	Fresh-cut	51.62	0–2	0–2	19.66	245
55	45	Annealed	40.11	10–18	0	17.53	276
60	40	Fresh-cut	52.00	1–3	0	9.06	239
60	40	Annealed	39.80	10–17	0	14.10	297
65	35	Fresh-cut	52.00	0	1–5	3.67	290
65	35	Annealed	33.00	6–10	0	5.00	335
70	30	Fresh-cut	55.00	0	14–20	3.45	316
70	30	Annealed	40.00	5–7	0	4.67	375
72.5	27.5	Fresh-cut	55.00	0	28–42	3.92	350
72.5	27.5	Annealed	45.00	0–3	0–4	3.76	450
75	25	Fresh-cut	55.00	0	40–60	5.64	258
75	25	Annealed	50.00	0	6–8	5.40	300

EXHIBIT, COMPOSITION, AND PHYSICAL PROPERTIES OF MODIFIED SILVER-TIN ALLOYS.

Formulæ.			How	Per cent.	Shrink-	Expan-		Crushing
Modifying metal.	Silver.	Tin.	prepared.	of mercury.	age.	sion.	Flow.	stress.
None	65	35	Fresh-cut	52.33	0	1	3.67	290
None	65	35	Annealed	33.00	10	0	5.00	335
None	66.75	33.25	Fresh-cut	51.52	0	4	3.35	329
None	66.75	33.25	Annealed	33.53	7	0	5.06	380
Gold 5	61.75	33.25	Fresh-cut	47.56	0	1	4.62	330
Gold 5	61.75	33.25	Annealed	30.35	7	0	6.07	395
Platinum 5	61.75	33.25	Fresh-cut	51.87	0	9	9.68	200–273
Platinum 5	61.75	33.25	Annealed	37.33	7	0	8.20	250–352
Copper 5	61.75	33.25	Fresh-cut	53.65	0	23	2.38	300–343
Copper 5	61.75	33.25	Annealed	35.60	5	0	3.50	416–450
Zinc 5	61.75	33.25	Fresh-cut	56.65	0	68	1.83	200–290
Zinc 5	61.75	33.25	Annealed	40.65	0	9	2.07	250–345
Bismuth 5	61.75	33.25	Fresh-cut	46.26	0	0	4.78	250–288
Bismuth 5	61.75	33.25	Annealed	23.67	6	0	5.58	308
Cadmium 5	61.75	33.25	Fresh-cut	57.57	0	100	6.40	225
Cadmium 5	61.75	33.25	Annealed	47.25	0	5	3.54	290
Lead 5	61.75	33.25	Fresh-cut	44.17	0	1	4.88	290
Lead 5	61.75	33.25	Annealed	32.76	10	0	7.18	276
Aluminum 5	61.75	33.25	Fresh-cut	65.00	0	445		
Aluminum 1	64.5	34.5	Fresh-cut	46.98	0	166	12.60	198
Aluminum 1	64.5	34.5	Annealed	38.26	0	48	17.90	213

The first class seems to be based upon the properties of $72\frac{1}{2}$ per cent. of silver and $27\frac{1}{2}$ per cent. of tin, the most important of which is the small amount of shrinkage which takes place when this alloy is converted into amalgam. The second class seems to be based upon the dual movement of 50 per cent. of silver and 50 per cent. of tin, which by

referring to Dr. Black's charts is seen to be only 2 points. Besides the two principal classes of alloys mentioned, there are in the market many of the alloys made and used previous to Dr. Black's work.

Townsend's original alloy of silver 42 per cent. and tin 58 per cent. is still used by some.

Flagg's alloys, especially the one containing silver 60 per cent., tin 35 per cent., and copper 5 per cent., are still in the market and used by some.

There are a dozen or more alloys made to supply the varied demands of the profession. Some of them have one or more prominent qualities, but, as a rule, they are not free from a reduction in volume at the time of and subsequent to insertion, nor do they seem to be based upon any particular principle, as are the two classes which have resulted from Black's work. Inasmuch as these alloys are also composed of silver, tin, copper, zinc, and occasionally gold, they are subject to the same consideration as far as physical and chemical properties are concerned. It would seem that dental amalgams can best be understood by dividing them into the two classes spoken of as high percentage silver alloys and low percentage silver alloys. The difference between the two can probably be best represented by first considering the most important properties of each constituent.

Silver unites with mercury in definite proportions, and through its comparatively strong affinity for mercury and its large proportions it largely controls the setting. It tarnishes quite readily in sulphuretted hydrogen and soluble sulphids. It increases in volume when amalgamated. It increases edge strength, lessens the flow, and because of its great tendency to crystallize and its property of going into solution in mercury slowly at ordinary temperatures it causes the alloy to amalgamate tardily and the mass to work hard.

Tin unites with mercury in all proportions at all temperatures, forming a weak crystalline compound. It retards the setting, decreases in volume when amalgamated, decreases edge strength, increases the flow, and imparts plasticity, thus causing the mass to work easily.

Copper unites with mercury with difficulty at ordinary temperatures, although in definite proportions it generally hastens the setting, increases edge strength, lessens flow, does not change appreciably in volume when amalgamated, and is easily tarnished by sulphuretted hydrogen and soluble sulphids.

Zinc unites with mercury easily and in definite proportions, increases in volume when amalgamated, hastens the setting, increases edge strength, lessens flow, improves color, and imparts a peculiar smoothness to the mass during amalgamation.

Gold when melted with the other constituents, as most of the present alloys are made, adds almost no desirable properties and adds one or two undesirable properties. It adds a little to the color and makes a very tough amalgam, but it imparts a peculiar pasty springiness which makes

it difficult to pack. There are some possibilities in the use of gold in small quantities, however, that are not fully developed and which look promising.

From the nature of metallic alloys we may assume that certain proportions of these constituents enter into combination and other portions are simply in a state of mixture or solution. From the similarity of the metals we may assume that energetic union has not taken place, and, as a result, the portions united chemically are not expected to have properties diverging widely from their constituents.

Since solutions and mixtures generally possess the properties of their constituents, we would expect a compound composed of these metals to be the sum of the properties of its constituents. Such seems to be the case with these alloys. A point to be observed in the consideration of these alloys is that one or two metals are used as the base of the alloy and the others as modifiers, the attempt being made to add to the properties of the basal constituents some of the properties of other constituents.

A consideration of the alloys now in use, with one or two exceptions, shows that the selection of these metals and the proportions of each has been made with reference to their physical behavior, special emphasis being placed upon decrease in volume, color, and strength. Fenchel,[1] however, has for some time been studying amalgams from a different point of view. He has taken a break in the cooling curve of any liquid (including melted metals) to indicate a change in physical constitution, and from this traced the crystallizing curve of some of these alloys in increasing proportions to each other. He has studied the structure of these alloys microscopically as well as with reference to alteration in form, resistance to stress, specific gravity, and electromotive force of currents set up in the mouth by different metals, all of which forms a very valuable part of scientific literature. Fenchel's[2] work may be said to follow more closely the chemical phases of alloys than the physical ones, while the work of others seems to be devoted largely to the physical properties.

It would appear that a clear understanding of the physical behavior of these alloys cannot be had without at least a working knowledge of their chemical behavior. For the present however, our knowledge of alloys most generally adopted (the two classes mentioned) is confined largely to their physical behavior. The principal difference between the two classes of alloys should be obvious. The first, with more silver, less tin, and some copper, is stronger, more stable in form, more free from decrease in volume, though it works hard and sets quickly. The second, with its high percentage of tin, low percentage of silver, and absence of copper is easier to amalgamate, sets slower, and is a little lighter in color. These two classes of alloys resemble some of the older

[1] Dental Cosmos, vol. l, p. 553, and vol. li, p. 1.

[2] For a study of Fenchel's work see his various papers in the Dental Cosmos.

as well as many of the newer ones by having some properties in common. Contraction and expansion, for example, seem to be phenomena accompanying the setting of dental amalgams. Dr. J. Foster Flagg and the previous workers seemed to attribute these properties largely to the composition of the alloy. Dr. Black pointed out that the annealing of the cut alloy increased contraction. It has been pointed out that the percentage of mercury used during amalgamation had its influence, although it can hardly be regarded as a cause of these phenomena, but rather a medium to facilitate further contraction in the already contracting alloys and expansion in already expanding alloys.

The writer has observed that the order of melting the different constituents, the temperature at which they were kept molten, the time that they were kept molten, the temperature at which they were cast, and the rapidity of cooling—each could be made to have its influence upon the behavior of these alloys. He has also noticed that the size and shape of the alloy filing had its influence upon contraction and expansion. When we consider that alloys containing 67 per cent. of silver and some copper dissolve tardily in mercury at ordinary temperatures, and can only be made to form a little true amalgam with the treatment given by dentists during amalgamation, it seems entirely within reason that the "cut" of an alloy has to do with its condition of contact, and oftentimes presents a typical concrete mass with the undissolved particles of alloy, corresponding to the bricks in the wall, and the true amalgam formed upon the surfaces of these particles corresponding to the mortar.

It is not the intention of the writer to convey the idea that the "cut" of alloys is an active cause of contraction or expansion, but rather a modifier of already existing contraction or expansion, in the same sense that an excess of mercury is a modifier of these movements. That the composition of alloys has to do directly with contraction and expansion seems to be well established.

With Flagg's work as a basis, Black seems to have established the contraction and expansion ranges for the metals generally used in the production of dental amalgams. His results have been questioned, but it would seem that it has been done mostly by those using the specific gravity method of measuring contraction and expansion which gives the actual volume, while Black's measurements were taken with a micrometer, which gives linear measurements. (See section on Methods of Measuring Change in Volume.)

Black has assumed that of all the properties which amalgams possess, nothing is of as much importance as freedom from contraction. He has regarded it as imperative that there must be absolute freedom from contraction and only a minimum of expansion. With this in view, as will be observed from his exhibit, he has shown that a minimum of contraction, after annealing, took place with 72.5 per cent. silver and 27.5 per cent. of tin. Reference to the foregoing pages shows that the alloys made after his plans do not contain this amount of silver. They show that

certain ranges are adhered to which seem to be from 65 per cent. to 68 per cent. The reason for not using 72.5 per cent. of silver seems to be that a substitution of about 5 per cent. of copper and a little zinc for an equal amount of silver would give the same minimum contraction and at the same time add some of the desirable qualities of copper and zinc.

Dental literature fails to show that any definite and fixed amount of silver, tin, copper, and zinc can be used and obtain freedom from contraction and expansion. Black states,[1] in describing his experiments with the silver-tin alloys, that because metals of a chemically pure nature are too expensive for use in dentistry, metals of a less degree of purity are used, and as a result no fixed formula is good for general use. His exact words are: "From this point another short course of alloys only 0.5 per cent. apart was necessary to find the exact balance which would produce an alloy that would absolutely lie still while hardening. When this was found, it was a good formula for that batch of metals, but not for another batch, for the purity might be different, and the formula for each new batch of metals had to be found. Therefore, no fixed formula could be good for general use. If it were possible to use chemically pure metals, a fixed formula would be possible, but such metals would be too expensive for use in dentistry."

The literature from many of the leading supply houses implies that their alloys are made after this plan suggested by Dr. Black, although some claim that a fixed formula is the basis of their products. A review of Fenchel's recent work, and the earlier work of Kirk and Burchard, each of whom have viewed more closely the chemical phases of alloys, would not suggest the plan offered by Dr. Black. The question, "Why does a fixed formula not give a definite movement during setting?" has been asked of the writer so many times by teachers and practitioners alike that it would seem as though the plan had not been understood nor accepted generally by the profession. All seem agreed, however, that the plan gives as good results and furnishes us with as good alloys as our present knowledge of the subject will permit. It is the manner of reaching the result about which there seems to be a difference of opinion. The plan implies more than the mere fact that impure metals will not give a definite movement. It implies that metals cannot be constantly obtained with a definite grade of impurity, for if a metal contained a certain impurity in certain quantities every time it was purchased, allowance could be made for it in the formula.

While, as a rule, native metals are not to be relied upon, there are some instances where the impurity can be determined and allowance be made for it comparatively easily. It is quite sweeping in its scope, however, to say that *refined metals* cannot be obtained which are quite uniform in their impurities. It is a well-known fact that the character of many alloys is altered by the manner of melting and casting.

[1] Operative Dentistry, vol. ii, 310.

Oftentimes a certain property of a given combination may be lost or obscured by repeated remelting. Most metallurgists are aware of the difficulty of maintaining uniformity in an alloy during the melting and casting process which is least for two metals and increases when three or four are required. Since practically nothing has been written by Dr. Black and those adhering to his plan of preparing alloys about this most difficult of all metallurgical processes, nor the character of these impurities, it would seem probable that too much importance had been attached to the presence of impure metals and too little to the manner of preparing them. The manner of preparing these alloys, however, should be regarded as a modifier rather than as an active cause of contraction and expansion. With this in view, it may be said that there are five factors which influence contraction and expansion, viz.:

Composition of alloy (primary cause).

Manner of melting, casting, and cooling alloy (secondary cause).

The kind of cut of the alloy (secondary cause).

The amount of annealing of cut alloy (secondary cause).

The percentage of mercury used to amalgamate the alloy (secondary cause).

A sixth factor might be said to influence these movements, viz., the manner of mixing the alloy and mercury, although it seems to be so nearly synonymous with the cut of the alloy that it may be left out of consideration here. (See Section on Mixing Alloys.)

Annealing of Alloys.—Dr. J. Foster Flagg seems to have been the first to call attention to the fact that alloys which were freshly cut behaved differently when amalgamated than the same alloys did after they had stood for some time. Dr. Black traced the phenomena through a great number of experiments, and finally arrived at the conclusion that the cut alloy is hardened by the violence in cutting, the condition thus produced being analogous to the condition of the same metals in hammering. His earlier observations led to the belief that motion brought about the change, but later experiments showed that it had no influence. Oxidation was thought to be a factor, but was finally eliminated as one of the causes. After a great many experiments it was proved that the change was produced by annealing or tempering, *i. e.*, a molecular alteration of the cut alloy. The temperature at which this is produced ranges from room temperature upward. If the alloy be subjected to room temperature for a year or more, the same effect is produced as when it is subjected to a higher temperature for a shorter time. It has been found that the low temperature and longer time of exposure bring about a more complete annealing. The change can be brought about by subjecting the cut alloy to the temperature of boiling water for about twenty minutes, although there is not quite the same quality to the alloy that there is when it is subjected to a temperature of 120° F. for from two days to a week. The amount of heat required to bring about the change is not the same for all

alloys, although each formula seems to change in many of its properties with this treatment. That this property of these alloys to change by so-called "aging" or "annealing" is a physical phenomenon, seems to be the opinion of Dr. Black[1] and of Fenchel,[2] but whether it is caused by hardening during the cutting process, as suggested by Dr. Black, is a question worthy of consideration by those interested in the cause of this peculiarity.

It is well known that the working of metals forces their molecules into unnatural positions, and that by annealing they are largely restored to their normal state. But it is also well known that the rate and manner of cooling of many metals may preserve in some cases and alter in others the mode of existence of the molecules at the time they were molten. It is also worthy of note in this connection that unequal stresses are set up in some castings by cooling the outer layers of the metal much quicker than the interior, thereby causing a compression of the interior by the outer layers.

By annealing, which is the reverse of hardening, the metal flows, and this tension is relieved. It cannot be stated definitely whether this hardness is produced by the casting or by the cutting process, although the remedy seems to be well under control. The effect of annealing is to remove expansion from those alloys which expand only, and increase contraction in those alloys which contract; to reduce the percentage of mercury required to amalgamate; to retard the setting; to facilitate amalgamation; and in *general terms* annealing may be said to increase both crushing stress and flow. The annealing process effects a reduction in expansion, an increase in strength and flow, reduces the percentage of mercury required to amalgamate, and facilitates amalgamation simultaneously up to a certain point. (See page 291, Test 6.)

At this point, which is different for different alloys, no further change is produced in contraction and expansion, but all the other changes continue with the annealing. The alloy continues to become softer, to require less mercury, to amalgamate easier, to flow a little more, and, instead of continuing to increase in strength, begins to *decrease* in strength.

The annealing process seems to have a zero point for contraction and expansion where no further change is produced by annealing, but *not so with any other property.* There is a *changing point* for crushing stress, where the alloy, instead of increasing with annealing, begins to decrease. This can be readily understood when it is considered that the annealing process is a softening process. Freshly cut alloy sets so rapidly because of its denseness and affinity for mercury that thorough amalgamation is impossible. The annealing removes this property of setting so rapidly, and gradually admits of a thorough amalgamation; but if annealing is carried too far the alloy becomes too soft to admit of the production of a filling of maximum strength. No one thing in the use

[1] Operative Dentistry, vol. ii, 309. [2] Dental Cosmos, vol. li, 1909, p. 7.

of alloys seems to be of such vital importance to the profession as an understanding of the foregoing phenomena regarding annealing.

Oftentimes alloys are purchased in quantities with the understanding that they *have been annealed* and that no further change will take place as time goes on. No perceptible change will take place in the well-made alloys in contraction, but the very best alloys will decrease markedly in strength, set much slower, require less mercury, and work very easily, within a year's time at room temperature.

Strength of Alloys.—Strength of alloys usually indicates those properties by which alloys sustain the application of force or strain without yielding or breaking, and may be considered under two heads, viz., crushing resistance and flow. Crushing resistance is that property by virtue of which these alloys resist force without *fracturing*, while flow is that property by virtue of which they resist force without *change in shape.*

Crushing resistance of these alloys may be treated (1) as a property of the alloys used to form amalgams, and (2) as a property of the amalgam mass. The crushing resistance of these alloys before they are combined with mercury is much higher than they are after they are cut and amalgamated, mercury increasing the plasticity of all its alloys. With this in view, it is obvious that within certain limits any alloy uncombined with mercury in the amalgam will increase crusning resistance. The crushing resistance of these alloys from which amalgams are made is controlled by the composition of the alloy, the amount of annealing, and probably (as mentioned before) the manner of casting and cooling. Silver adds to this property, copper does likewise, and tin detracts from it markedly. Zinc cannot be said to add to crushing resistance, it being much better than tin in this respect and a little poorer than silver and copper. The crushing resistance of amalgam prepared from these alloys presents not only the same phenomena as the alloys, but the additional complications arising from the union of the mercury with alloy.

The following table of results demonstrates that dental amalgams have no definite crushing resistance.[1]

Alloy No. 1.	Per cent.	Alloy No. 2.	Per cent
Silver	68.00	Silver	65.50
Tin	26.50	Tin	25.50
Copper	4.20	Copper	6.00
Zinc	1.30	Zinc	3.00

Age of amalgam	Crushing resistance. Alloy No. 1.	Crushing resistance. Alloy No. 2.
1 day	435 pounds	452 pounds
2 "	478 "	462 "
4 "	485 "	453 "
24 "	493 "	447 "
42 "	497 "	447 "
85 "	475 "	433 "
205 "	414 "	367 "
341 "	344 "	310 "
491 "	187 "	163 "

[1] See a paper by the writer in Dental Review, April, 1907.

The two alloys used for these tests were selected from the market not simply because they represented some of the best products (all things considered), but because they represented about the maximum and minimum precentages of zinc to be found in these products at that time. The fillings made from these two alloys were allowed to stand, and at different intervals six fillings were crushed at a time and an average taken as the crushing resistance of the alloy at that time. One thing to be observed is the increase in crushing resistance of both alloys up to a certain point, after which there was a decrease in crushing resistance for a much longer time.

Another feature of interest is the difference in time required for each alloy to reach its maximum crushing resistance. The explanation offered for the variation in amount of crushing resistance was briefly this: At the time of making the fillings they were composed of undissolved particles of alloy surrounded more or less completely with alloy dissolved in mercury, forming a kind of cementing substance. From this time until the time the maximum crushing resistance was reached the cementing substance was passing through the process of solidification.

From the time of reaching the maximum crushing resistance (probably from time of amalgamation) there was a gradual breaking down, through some of the various ways previously referred to under nature of dental amalgam alloys, of the undissolved particles of alloy. As an explanation of the difference in time required for the maximum crushing resistance to be reached, it was stated that it was due to the ease with which the alloy amalgamates, and this depends obviously upon the composition of the alloy. In this case the alloy containing the least silver and the most zinc reached its maximum crushing resistance first. From the nature of the metals this should be expected. Since the time of these tests other observations have been made which not only confirm the ones already mentioned, but appear as indisputable proof that these alloys are changing in crushing resistance at the end of three years.

These tests, according to others started a little later, appear to indicate these changes in crushing resistance, although they were not carried on long enough to obtain all the change. Later experiments tend to show that after the decline in crushing resistance at about the end of one and one-half years there is another increase for a year or more. It may be said that a cylinder $\frac{1}{8}$ inch by $\frac{1}{8}$ inch of one of the best high percentage silver alloys, properly amalgamated, will resist a force of from 450 to 500 pounds after it has stood a week at room temperature. A cylinder of the same dimensions, under the same conditions, of one of the low percentage silver alloys will resist a force of from 150 to 250 pounds. These conditions affecting the crushing resistance of dental amalgam alloys may be modified by the condition of the cut of the alloy, the manner of incorporating the alloy and mercury, the amount of mercury used during amalgamation, and the amount of mercury left in the filling.

A comprehensive consideration of the actual condition of the amalgam mass at and subsequent to insertion reveals that these hitherto regarded as primary causes of a modification in the crushing resistance of alloys are in reality adjuncts to the real cause. A coarsely cut alloy, for example, may be ground in a mortar with sufficient mercury by one operator until it is quite fine, while it may be hastily mixed with too little mercury and inserted by another. The interior of the two fillings thus made cannot be regarded alike either from a chemical or physical standpoint, neither can there be anything but a great diversity of changes in crushing resistance expected from the two when we consider carefully the thermochemical relations of mercury with the constituents of the alloys used to form amalgams. The amount of mercury left in the filling influences crushing resistance in at least two ways, viz., by its mere presence, and by its action with the undissolved particles of alloy.

If mercury be present in too large quantities, its presence, because of its liquid state, lessens crushing resistance markedly. On the other hand, if there be too little present, the crushing resistance will be lessened, due to incomplete amalgamation. The presence or absence of mercury obviously facilitates or retards the breaking down of the undissolved particles of alloy.

Flow of Amalgams.—A solid metal can flow like a viscous fluid if sufficient pressure is applied (Hiorns). The property seems to be different with different metals and varies with different forms of the *same* metal. Some metals with a distinctly granular structure seem to flow less than the same metal when in a less granular structure, though the tenacity and elongation of the two forms may be nearly identical. The differences in the rate of flow between different metals depends largely upon their *plasticity*, by virtue of which they yield to the pressure and allow the molecules to slip over each other and assume new positions. Dr. Black says:[1] "If we subject pure silver, say a block 0.1 inch square, to 300 pounds it will yield a very little almost as soon as the pressure is applied. Then it will yield no more until the weight is increased. If we try a similar block of tin in the same way we find it softer. It will yield sharply at 25 pounds, and if we leave it under this pressure without increasing it, it will continue to yield until it has all crawled out from between the points or been reduced to a thin sheet. Therefore, the tin is not only a softer metal, but it has a physical property totally different from any possessed by silver, the property of continuous flow under a given pressure." This indicates the effect of tin and silver upon flow, though it implies that the flow of tin is a peculiar property rather than that it is a property of all metals, tin being one possessed of a high rate of flow.

A hard metal like silver has an *elastic limit*, which must be exceeded and the pressure maintained in excess if a continuous flow is produced, while a soft metal like tin has practically no elasticity, and is therefore

[1] Operative Dentistry, vol. ii, 317.

capable of being changed in form with almost any pressure. The composition of the alloy controls largely the property of flow, the hard and elastic metals reducing it and the soft ones increasing it. The effect of annealing upon flow depends upon the composition, some formulæ being affected more by annealing than others. Generally speaking, the softening of an alloy by annealing increases flow, although with some formulæ flow may be slightly decreased by annealing.

The manner of incorporating the alloy and mercury, percentage of mercury used during amalgamation, the condition of the cut, and the amount of mercury left in the filling each modify flow, although not with regularity even in a given alloy. The least change in composition so modifies flow that each of these phases must be considered separately with each formula. An excess of mercury left in the filling, however, increases flow quite regularly, there being some exceptions in the ternary amalgams, which are high in silver and low in tin. The property of flow depends largely upon softness and absence of elasticity, and is at its maximum in alloys known as low silver alloys.

FIG. 295



A

FIG. 296



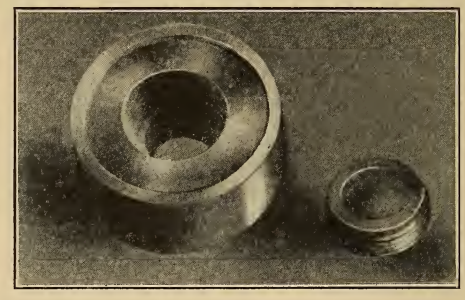
B

Spheroiding of amalgams is a phenomenon associated with flow and increase in volume. It has been held that amalgams possessed a strong tendency to become spherical in shape, due to the influence of mercury, which is spherical in shape when divided finely. This influence which mercury is supposed to exert seems to be a misconception of the cause of the tendency to spheroid. Mercury is spheroidal or globular in shape when divided somewhat, the smaller the particle the more nearly a sphere. There seems to have been a tendency to regard this as a property peculiar to mercury. This is not true. The property is possessed by other metals when in a molten condition.

The following illustrations show a spheroided filling produced by an alloy which increased in volume and flowed easily. It was composed of silver, 49 per cent.; tin, 49.1 per cent.; and zinc, 1.9 per cent. Fig. 295 shows the surface of a filling made from this "plastic" alloy and kept in the thermostat at body temperature for eight months. The surface is seen to be spheroided. Fig. 296 shows a companion filling like that of Fig. 295, except that the walls of the test-tubes are highly polished, this being accomplished by making the test-tube with removable bottom,

as seen in Fig. 297. It may be seen that the filling Fig. 296, instead of spheroiding, has risen nearly as much at the borders as it has at the centre of the filling. The filling Fig. 295 has assumed a much more spheroidal surface than the one Fig. 296, due apparently to the walls of the cavity being purposely roughened. This spheroidal tendency seems to disappear somewhat with alloys high in silver and copper, these alloys possessing less flow. It has not been produced to any extent in alloys which do not expand decidedly and flow comparatively easily, although irregular expansions and contractions appear to produce in some instances bulged surfaces and in others concave surfaces in alloys possessing little flow and expansion. The consistency of the mass and density obtained in working and packing seem to facilitate irregular expansions and contractions. Alloys which are in a liquid or semisolid condition while being packed will show a tendency to spheroid, not because of expansion, but simply because they are not solid. Often-

FIG. 297



times the packing of amalgam results in the production of layers which have the mercury well pressed out and others which have large excesses of mercury, and during the setting process the mercury becomes equally distributed, with the result that the more dense layers bulge, while those which are less dense become flattened or even concave.

Thermal and Chemical Relations.—Amalgam, like gold and other metals, is a conductor of thermal impressions. Just where amalgam stands as a conductor of heat and electricity is not known, although it can safely be placed quite near to gold. The composition of the amalgam will influence its conductivity. Any rise in temperature will usually retard and a fall in temperature will increase conductivity, although the resistance of alloys to conductivity does not always behave in a manner that would be expected from the nature of their constituents. Besides being subject to change in volume during and subsequent to their setting, amalgams expand when heated and contract on cooling. The metals of which these amalgams are composed, within certain limits, expand or contract in proportion to the rise or fall in temperature, but it cannot be said with certainty that this is true of these amalgams. Certain anomalies which are known to exist make it

seem possible that certain temperatures with certain formulæ might result in a variation from the general rule. Dental amalgams are practically insoluble in the fluids of the mouth. The common solvent found in the oral cavity, lactic acid, affects them but little. There is, however, a constant wasting away of many amalgams due to the formation of salts which are soluble in the oral fluids. Amalgams that are high in copper furnish an example of the constant wasting which may be due to the formation of the green basic carbonate in small quantities, or salts from the action of hydrogen sulphid and soluble sulphids. The two principal classes of alloys now in use are not affected this way to any appreciable extent.

There are probably no alloys in use which exert any particular influence upon the tooth tissues except those high in copper. There are one or two alloys heralded as great tooth preservers, not simply because they are free from contraction, expansion, and flow after insertion, but because they possess "antiseptic properties." A critical examination of them fails to reveal any reason why they should exert any such influence. The action of copper amalgam upon the tooth tissues has been studied by Miller, Fletcher, Witzel and others, and the general opinion seems to be that it possesses antiseptic properties.

Use and Manipulation of Amalgam.—The advent of better methods and facilities for the construction of inlays and crowns each year seems to reduce greatly the amount of amalgam used. It can, however, hardly be excluded from any dental practice without at least an occasional injustice being done the patient as well as the operator.

As a general rule, amalgam is inserted in places obscured from view and places difficult of access. Among the former may be mentioned cavities on the lingual surfaces of all the teeth, distal cavities in cuspids, bicuspids, and molars, mesial cavities in the second and third molars, buccal cavities in the second and third molars, and cavities on the occlusal surfaces of bicuspids and molars. The principal cavities which are so difficult of access as to demand amalgam are those situated on the disto-buccal and distal surfaces of the second molars and all cavities in the third molars. Even these cavities are not always difficult to fill with other and better materials than amalgam. The preparation of the cavity for the reception of amalgam should be done with as much care as for the reception of any other material. The teeth should be separated, and any overhanging gum tissue removed previous to the preparation of the cavity. The rubber dam should be adjusted whenever possible, so that disinfection of the cavity may be accomplished and the filling inserted in the absence of the oral fluids.

The thing of greatest importance to the dentist is the selection of the alloy. Many have doubted the tooth-saving qualities of the high percentage silver alloys designed by Black over those of Flagg and the

older workers. Many laud the low percentage silver alloys, designed not by Black, but by the students of his work, because they are very light in color and work easily, while others adhere to copper amalgam. In the selection of an alloy from which to make amalgam fillings it must be remembered that the qualities most desired are not all incorporated in any one kind of amalgam. Copper amalgam, for example, will unquestionably save more teeth than any other kind because it is practically free from change in volume and possesses antiseptic properties; but it turns so dark in the mouth and causes so much galvanic trouble that its use is very questionable. The low percentage silver alloys are light in color and work easily because they contain no copper and a great deal of tin; but they flow so badly, have so little strength, and change so much in volume that their use is also questionable. The data obtainable show that the alloys known as high percentage silver alloys made by reliable manufacturers possess the greatest number of desirable qualities.

It is *very important* that an alloy made by a competent maker be selected, since there is probably no product in dentistry, and it is doubtful if there ever will be, that is subject to more variations and is really less understood. There are certain principles which the competent person will have to guide him, and certain peculiarities about these bodies which a few have discovered and mastered. No one desiring to serve his patient's best interest will make his own alloy without some years of study and a generous investment in equipment. He may save some teeth, in fact he may save many, but such alloys cannot possess *uniformly* the greatest number of desirable qualities. The high percentage silver alloys are made by some manufacturers in two and three grades as regards the setting. They are of the same composition, cut just the same, and marketed just the same, except that some packages may be marked "slow setting," some "rather rapid setting," and others "rapid setting." The difference in their production is in the amount of annealing given them, annealing causing them to set more slowly, and their behavior is usually more marked.

Alloys marked "rapid setting" will require much more mercury to amalgamate them if they have not been in stock long enough to become annealed. They will set so rapidly that it is difficult to pack them properly, even in cavities of easy access, and almost impossible to insert them where there is not ready access. The amount of expansion that will take place subsequent to insertion is much greater with improperly annealed alloys. The finished product is represented by alloys marked "slow setting." Some manufacturers make their high percentage silver alloys in one grade only. These alloys will have no mark to designate their manner of setting.

The alloy to be selected for general use is the finished product, although the occasional use of "rapid setting" alloy when the patient

cannot be seen by the operator to finish the filling seems to be desirable. It should be remembered that while alloys marked "rapid setting" expand more than those marked "slow setting," contraction and expansion are not controlled by the manipulation of them during amalgamation and insertion. The operator may modify these movements, but he cannot control them, the controlling factor being composition.

In choosing an alloy, it should be remembered that the *only* property which can be controlled by the operator is strength, and even then the alloy must be properly made or a strong filling cannot be produced.

A strong filling cannot be made from a poor alloy, although a weak filling may be made from a good one. The amount of alloy necessary for the filling should be placed in a small ground glass or Wedgwood mortar and ground with the required amount of mercury until the mass becomes coherent enough to be turned into the palm of the hand conveniently, after which it should be kneaded *rapidly* and *vigorously* for from three to five minutes, depending upon the coarseness of the cut, amount of annealing, and composition of the alloy.

A complete union of the alloy and mercury cannot be effected at ordinary temperatures. The operator must be guided in amalgamating these alloys by the consistency of the mass. It should be fine grained and smooth, and tough enough to be rolled out into a long roll without breaking before the mixing is discontinued.

The amount of mercury to be used with a given weight of alloy is slightly more than the weight of the alloy. The proportions given by most makers of high percentage silver alloys are, approximately, alloy, 5 parts; mercury, 7 parts, by weight. These proportions are as nearly correct as can be determined by experiment, although 7 parts of mercury will be found none too much for alloys marked "rapid setting." The low percentage silver alloys of all grades will require less mercury. It will seldom be found necessary to use more than equal weight of mercury for a given weight of alloy, to make a smooth, fine-grained mass. The amount of mercury to be used with a given amount of alloy of known composition is a question which cannot be answered unless the "condition of the cut" and the age of the alloy are known.

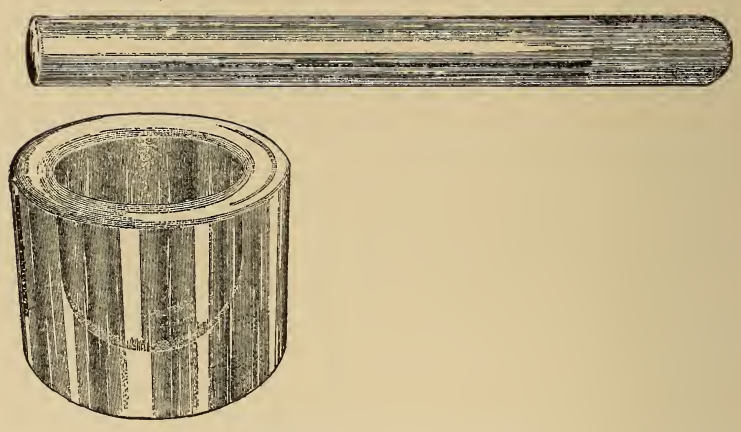
The condition of the cut of an alloy will oftentimes affect the rapidity with which the alloy becomes annealed in the warehouse or office.

All alloys require less mercury as they become annealed, hence the proportions given by makers of alloys are correct for a comparatively freshly made alloy only.

The older any alloy becomes the easier it works, the weaker it is, and the *less mercury it requires*, although if properly made it will not contract appreciably. It may be noted that manufacturers having similar products recommend slightly different amounts of mercury to be used with a given amount of alloy. Some products may be marked: "Use 5 parts of

alloy with 7 parts of mercury;" "4 parts of alloy with 5 parts of mercury;" "9 parts of alloy with 11 parts of mercury," etc. Chemical analyses show many of these alloys to be nearly identical in composition, but there is some difference in the "cut" of them, a little difference in the amount of annealing, and probably some difference in the manner of casting and cooling, which accounts for the variation of about 10 per cent. in the amount of mercury required. The correct amount of mercury to be used during amalgamation does not mean the amount of mercury to be left in the filling. It means that a slight excess of mercury should *always* be used to start the filling, and as soon as it is noticed it should be removed. Dr. Black states[1] that "it is certainly best to have just the right amount," but in the same sentence states that "superfluous mercury does little harm if removed as soon as noticed."

FIG. 298



Fletcher's glass mortar and pestle.

Dr. Black remains practically silent on the subject of "permanency of form" or changes in amalgam subsequent to insertion. Consistency of the mass seems to be a prominent factor with him. This is unquestionably a vital point in the packing process, but an amalgam which packs nicely may be the most unstable kind.

The factor of supreme importance in the production of a stable amalgam is a fairly complete solution of the alloy in the mercury. This can *only* be produced by the use at all times during the amalgamation process of slightly more mercury than makes a mass of the consistency to pack well. As soon as the mass begins to stiffen and shows a tendency to set, any surplus mercury should be removed. There is not even a remote possibility of an operator producing a true amalgam out of modern high percentage silver alloys under ordinary conditions. The best that can be done is to produce as much true amalgam as possible around the

[1] Operative Dentistry, vol. ii, 322.

undissolved particles of alloy and yet keep the mass of a consistency to pack well. The latter often depends upon the presence of a certain number of undissolved alloy particles.

Alloys low in silver and those high in silver that are very old may dissolve so completely in mercury that the mass is too soft to pack well. A perfect filling cannot be made with them.

The ultimate aim of the operator should be the production of a mass of amalgam that is both stiff and tough and with the alloy well into solution in the mercury. To accomplish this more mercury than is to be left in the filling should be used to start amalgamation. This amount is stated on the packages of alloy, and is correct for freshly made alloys. Alloys one year old or more do not require as much mercury. The alloy and mercury may be weighed on a balance or turned out approximately correct by an experienced operator from the containers. It is immaterial whether the exact amount of mercury is weighed or not, as the operator never knows whether these proportions are correct. It is *convenient*, however, to have them weighed in the proportions the maker has determined for fresh alloys, since a little mercury is easily removed during the amalgamation process if it be found necessary. Earlier observations of the writer led to the belief that alloy and mercury should be determined and weighed carefully, as in that way a mass was obtained of a consistency to pack well; but later observations on the changes occurring in these bodies subsequent to insertion lead to the belief that while the packing of an alloy is a vital point it is not of so much importance to the life of the filling as to have the alloy worked with sufficient (though not enough to make a sloppy mass) mercury at all stages up to the packing.

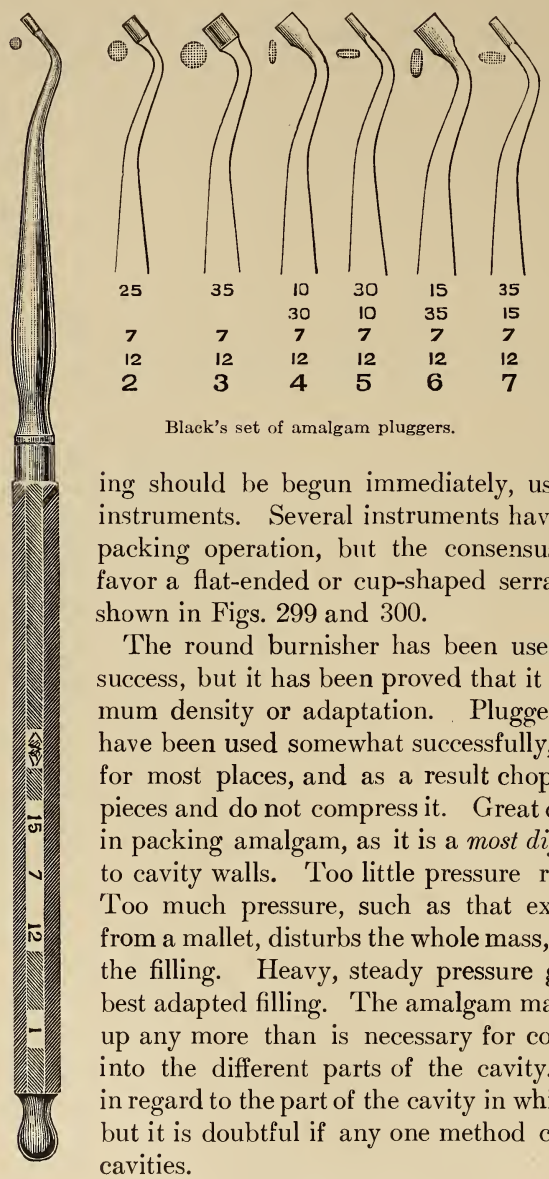
After the alloy and mercury have been ground in a mortar, then turned into the hand and worked vigorously for a few seconds, it should be noted whether the mass is becoming sloppy. If it is, a little mercury should be removed *quickly* between the thumb and forefinger. The mass should not be put into pliers, chamois skin, muslin, or anything else, as these processes require too much time. Surplus mercury should be removed *quickly*, or the mass stiffens so that the object of the operation is partially or wholly defeated. The mass should be quickly turned into the hand and again kneaded vigorously. If it again appears a little sloppy, remove some mercury as before. Do not remove too much mercury, or the alloy will not be anywhere near completely into solution. This process should be repeated three or four times, the last time using all the pressure that can be exerted in removing the excess mercury, so that the mass will be stiff enough to enable it to be packed well. A repetition of this process three or four times usually consumes from three to five minutes and results in a tough, stiff, and fine-grained mass.

The question might then be asked, "What is an excess of mercury?" And it might be answered in a general way by saying that it is the

difference between the amount used to amalgamate the mass and the amount that should be left in the filling.

Any amount of mercury left in the filling over and above an amount which makes a stiff, tough, and fine-grained mass of amalgam would, of course, be regarded as superfluous. Every step in the amalgamation process should be done rapidly, not allowing the amalgam to lie still. If the mass lies still a few seconds it stiffens so much that the particles of alloy are not broken down in the mixing and surplus mercury is usually retained in the mass. The packing should be begun immediately, using flat-ended serrated instruments. Several instruments have been designed for the packing operation, but the consensus of opinion seems to favor a flat-ended or cup-shaped serrated instrument such as shown in Figs. 299 and 300.

Fig. 299



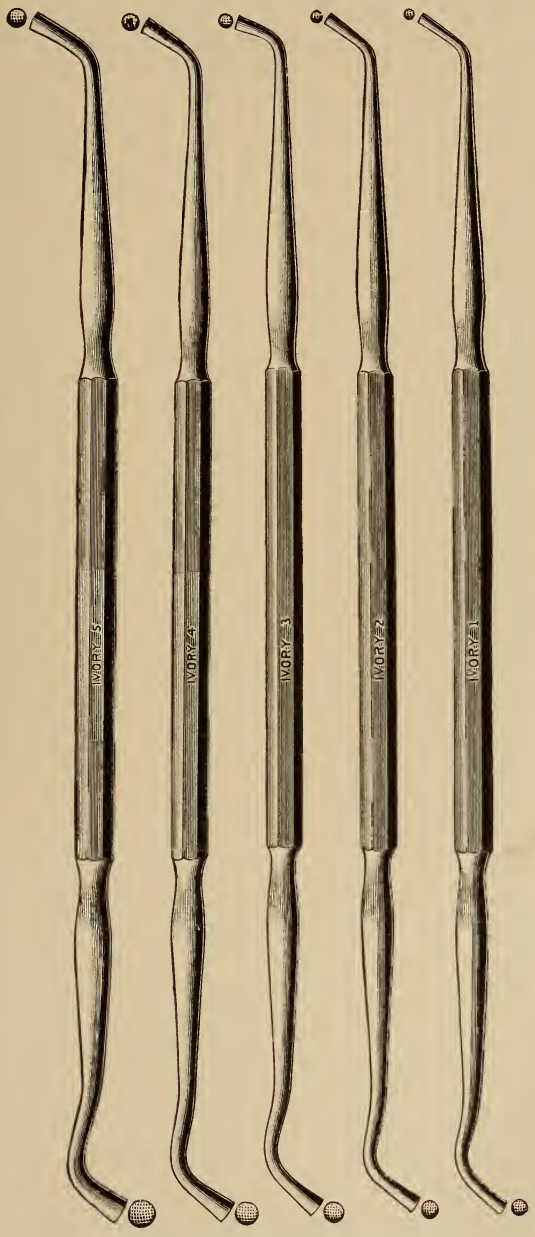
Black's set of amalgam pluggers.

The round burnisher has been used with some degree of success, but it has been proved that it does not give the maximum density or adaptation. Pluggers used for foil fillings have been used somewhat successfully, but they are too small for most places, and as a result chop the amalgam mass to pieces and do not compress it. Great care should be exercised in packing amalgam, as it is a *most difficult* material to adapt to cavity walls. Too little pressure results in a weak filling. Too much pressure, such as that exerted by sudden blows from a mallet, disturbs the whole mass, and as a result weakens the filling. Heavy, steady pressure gives the strongest and best adapted filling. The amalgam mass should not be broken up any more than is necessary for convenience in placing it into the different parts of the cavity. Much has been said in regard to the part of the cavity in which to begin the packing, but it is doubtful if any one method can be carried out in all cavities.

In all cases an effort should be made to *wedge* the amalgam, piece after piece, between the opposing walls or between one wall and the already condensed amalgam, finishing by wedging some amalgam

between the main mass and the cavity walls. Experience will teach how much force can be used in the wedging and what size of pluggers will not chop the mass to pieces. Instruments of varying sizes must be in

FIG. 300



Ivory's set of five amalgam carriers and pluggers.

readiness on the table, so that the operator has at his immediate command instruments that will compress and wedge amalgam into any pocket or crevice that may appear during the operation. Amalgam to be packed properly *must be stiff.* Soft amalgam cannot be packed to make even a fair margin when examined under the lens. It is in this part of the work that the modern high percentage silver alloys exceed all others, the low percentage silver alloys with no copper scarcely deserving comparison. The cavity must have four walls if any degree of compression is obtained. With the great variety of matrices and matrix retainers provided by the manufacturers, together with the facilities at the operator's command for making special matrices, there is seldom occasion for inserting an amalgam filling without the cavity having four walls. (See Chapter X on Matrices.)

The cavity should always be filled to overflowing. Amalgam should be packed with force, and with as large pluggers as are consistent with the operation, upon the orifice of the cavity and *left until the mass has become hard* before any of it is removed. After the mass has hardened somewhat, surplus amalgam should be removed by carving toward the borders with sharp plastic instruments or excavators, so that amalgam once packed along the margin and allowed to stiffen will not be disturbed. Attention may be directed to the fact that this can only be accomplished with the high percentage silver alloys. They excel all others in this feature as well as in all features of the packing process.

Only very light burnishing should be done at the time of insertion of an alloy, lest the margins be disturbed. The matrix should be removed with great care, or it may disturb the margins or even the bulk of the filling. An amalgam filling should be finished in the same manner as a gold filling after it has "fully set," but since this time is indefinite (see section on Strength), varying with different alloys, different manipulation and different ages of the same alloy, no definite time can be given for the final finish of the filling.

If the filling is given its final finish prior to its reaching its maximum hardness the best finish cannot be obtained. Generally speaking, forty-eight hours is sufficient to elapse between the insertion of amalgam filling and the time of giving its final finish, although a week is better.

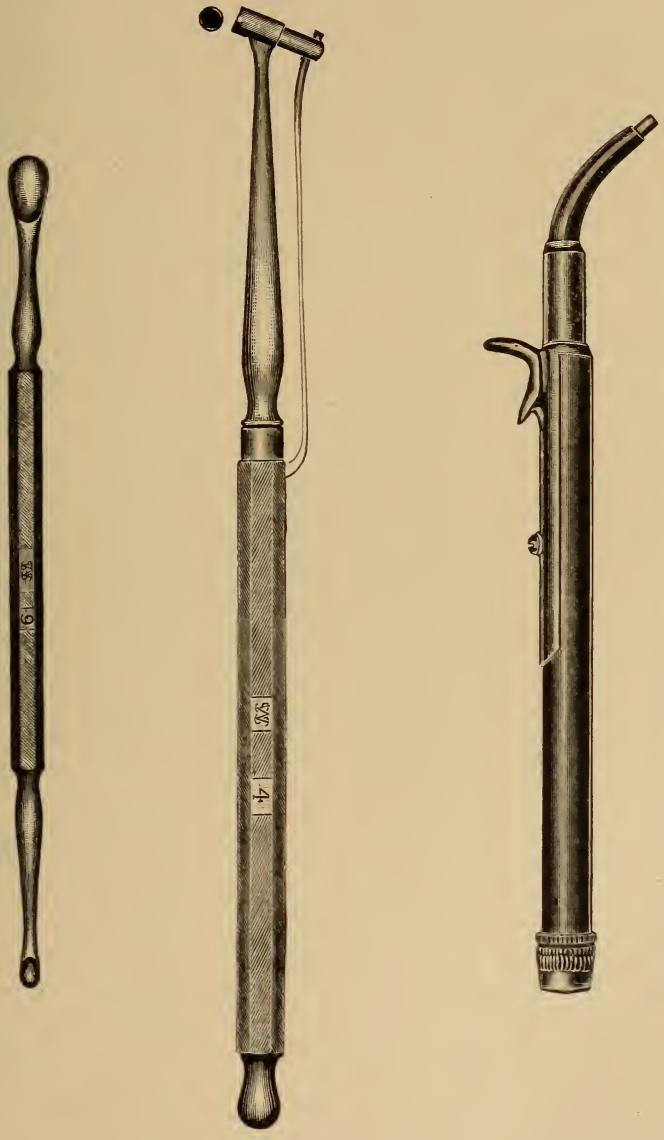
Amalgam fillings should be finished repeatedly. Not more than a year should elapse after the insertion of an amalgam filling before it should again have its margin polished and burnished.

Attention has been called to the fact that alloys have bulk changes after as well as at the time of insertion. This often causes the filling to appear spheroided, tilted, warped, or otherwise distorted within a year or two after insertion. Such fillings should be ground down with small stones and the surface again finished.

Numerous instruments have been devised for carrying amalgam from the table to the cavity, and for finishing the filling after it has stiffened.

Fig. 301 shows an instrument with a spoon at each end which may be used with advantage in carrying amalgam in almost all cases. Fig. 302 shows a somewhat different device, consisting of a tube into which is fitted

Fig. 301 Fig. 302 Fig. 303



a plunger, both of which are on a regular instrument handle. This instrument is useful for carrying amalgam to remote and inaccessible cavities, as enough compression can be given to the amalgam by the

plunger to make it remain in the cavity, a feat which cannot always be accomplished with the spoon instrument. Fig. 303 shows an instrument similar in principle, designed by Dr. H. W. Arthur. It is quite as useful as the one shown in Fig. 302 in all cases, and much more useful in many cases. The sleeve and plunger are constructed on a curve. They are long enough to enable the operator to discharge the tube with considerable force by means of pressure on the finger piece located on the plunger some distance from the end of the instrument. Fig. 300 shows the combination pluggers and carriers of H. W. Ivory. The ends of the instruments used for carrying amalgam are cup-shaped and serrated, and the amalgam is carried by being wedged into the serrated cups.

During the packing operation mercury is often removed from the amalgam mass and remains upon the surface. This is almost always true if the operator uses a mallet to give sharp blows, but is not very marked if the mass has been worked properly and the excess mercury removed by good, firm pressure just previous to packing, when the regular amalgam pluggers are used. The use of quick blows, as has been mentioned before, is bad practice, since it disturbs the amalgam mass, even when large pluggers are used, and usually forces too much mercury to the surface. As fast as mercury appears at the surface during packing it should be removed hastily with an excavator or other instrument and more amalgam inserted into the cavity.

If there is no easy access to the cavity, pressure enough to bring mercury to the surface will seldom be exerted. This is also the case if the matrix is not used. It is quite generally true that if a little mercury is not removed during the packing, the latter has been faulty. Gold foil, silver foil, and tin foil have been used to absorb the excess of mercury appearing at the surface of amalgam fillings, and little harm has probably resulted, although this practice cannot be said to add to the qualities of the amalgam. New alloys are formed upon the surface when any one of these materials is used, and experiments have proved that mercury and *one* metal do not form an alloy having the most desirable qualities.

When tin foil is used to absorb mercury appearing at the surface a soft non-crystalline, shrinking alloy results. Similar comment may be made upon the use of the other materials, gold being no exception.

Mercury which has appeared on the surface during the packing, providing the packing has been done with care, should be removed and not used again without being redistilled. The affinity of such mercury for other metals is probably weaker, even though it remains liquid.

It is possible that the presence of other metals in mercury may be found to improve its different qualities, but it has not yet been done. On the other hand, mercury which has been removed from amalgam during packing has almost invariably been found[1] to contain more tin than

[1] The author.

other constituents. Dr. Black's later observations seem to confirm this,[1] but in the same chapter he states that "if the alloying is a perfect combination I have reason to believe that no one metal will be dissolved more than another." It is a fact, however, that when two metals are cooled, certain alloys of these metals may solidify first and a more fusible alloy of these metals is left, and is known as the eutectic alloy of these metals. It is a general rule that this defect is intensified when four or five metals are used, as is the case in the production of dental amalgam alloys. With these facts in view we may assume that an ingot of alloy before it is cut contains quantities of globules or strata of eutectics which may be more soluble as well as more fusible. Mercury which has had ever so slight a contact with alloy should be discarded, since it will pick up some of the alloy and have its affinity partially satisfied.

General Considerations.—Washing Amalgams.—Much importance has been attached to the washing of amalgam just prior to its insertion or during the mixing process. Such substances as sodium carbonate, dilute acids, ether, chloroform, and alcohol have been used, but with doubtful value. The only advantage in washing amalgam is to remove some of the metallic salts which form upon the surfaces of the particles of cut alloy. It has been stated that washing increases shrinkage (Flagg), but this can easily be accounted for when it is considered that alloys free from shrinkage have been made only since Black's work. Washing amalgam with such substances as chloroform and alcohol will loosen the metallic salts sufficiently to permit the mercury to act more energetically. As a result, the filling will be at the time of insertion a little lighter in color, usually a little stronger, and the mass will set somewhat faster. Washing usually consumes enough time to allow the mass to stiffen somewhat, and in this case it is a decided injury to the filling. The material used for washing generally remains to a considerable extent as foreign matter in the filling. This in no case improves the integrity of the filling, and in some cases works marked injury.

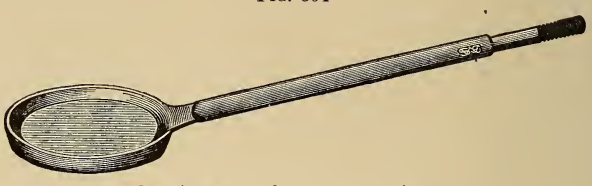
Empirical Methods of Mixing Alloy and Mercury.—Since the introduction of amalgam as a filling material, many have attributed their success with amalgam to some particular method of incorporating the alloy and mercury. Some have used the mortar alone, others the hand alone, and still others, various rubber receptacles. Many dentists seem to have lost sight of the fact that they are attempting to amalgamate a hard alloy. As soon as a little alloy is dissolved the mass stiffens somewhat, and if the amalgamation is not carried to completion *quickly*, large particles of alloy remain undissolved. This is particularly true when the hand alone or a rubber finger cot is used. Alloy must be broken down quickly if it is to be done as completely as possible. It has been suggested that perspiration from the hands injures the amalgam. This is

[1] Operative Dentistry, vol. ii, 318.

true only to the extent in which it remains as foreign matter in the filling, and with ordinary precautions this injury is imperceptible. A small mortar (see Fig. 298), preferably Wedgwood, for starting the amalgamation and the hand for its completion, seems to be the only equipment used by those who are studying the subject carefully.

Copper Amalgam.—Copper amalgam differs so markedly from all other amalgams, both in composition and behavior, that it deserves separate consideration. The foregoing data apply only in slight degree to copper amalgam. It is an alloy of copper and mercury, and may be made by adding freshly precipitated and washed metallic copper to an excess of mercury until the solution is complete; the excess mercury is then removed by compressing the mass in chamois skin. The portion which does not pass through the chamois skin is packed into moulds and allowed to stiffen. The product can be purchased in the form of small tablets, which may be softened by heating gently in a spoon (Fig. 304), after which it may be moulded and packed into the cavity. Many dentists have made copper amalgam by grinding copper filings in a mortar with dilute acids and washing with a variety of substances immediately

Fig. 304



Heating spoon for copper amalgam.

before insertion of the amalgam. A far better method, and one which yields a product of greater purity and uniformity, has been suggested by Dr. E. C. Kirk. It is done by precipitating the copper directly into the mercury by electrolysis. "This may be done conveniently," says Dr. Kirk, "by pouring a quantity of mercury into a suitable glass vessel —a small battery jar, for example—and suspending a thick plate of copper, by means of a wooden support, some distance above the surface of the mercury.

"A saturated solution of cupric sulphate is then poured into the jar until the copper plate is completely submerged. The cathode pole of a battery or other source of electrical current is then connected with the layer of mercury, and the anode with the copper plate. All of the cathode electrode that is in contact with the cupric sulphate solution should be insulated with gutta-percha, and only the point which is in contact with the mercury left exposed. The passage of the current causes solution of the copper from the anode and deposits it in the mercury continuously as long as the foregoing conditions are maintained. The precipitation should be continued until the mercury is saturated, which

will be evidenced by the appearance of the characteristic red color of the excess of copper at the cathode pole.

"When the saturation point has been fully reached the mass should be washed, first in dilute hydrochloric acid and then in water, dried and compressed, as is usual with this amalgam when prepared by the ordinary process." Copper amalgam prepared in this way does not change in volume as a result of the union of mercury with the copper, either in the mixing or subsequent to its insertion into the oral cavity. The only alteration in form that occurs is the comparatively small one resulting from the thermal changes. It is antiseptic. These two qualities make one of the best tooth preservers now in use, although it has other qualities so undesirable as to exclude its use in a great majority of cases. It turns almost black in most mouths, has a peculiar metallic taste, is sometimes a marked cause of voltaic disturbance, and if moisture through any cause enters between it and the walls of the tooth the latter becomes discolored. Often, although no visible leakage of the filling is apparent, there is discolored tooth tissue, due probably to the absorption of the salts of copper into the dentinal tubules. Copper amalgam is not quite as indestructible in the fluids of the mouth as other amalgams, as it readily forms salts which are either dissolved or carried away by abrasion. This is commonly shown by a sort of cupping out of the surface of the filling.

Classification of Amalgams.—Amalgams may be divided into classes according to the number of constituent metals. A binary dental amalgam may be represented by copper and mercury or palladium and mercury, each of which has a very limited usefulness in dentistry. Some of the older alloys of silver, tin, and mercury, such as that designed by Dr. Townsend, represent what may be called a ternary dental amalgam. Amalgams of silver, tin, copper, and mercury, such as designed by Dr. Flagg, may be said to be quaternary dental amalgams. This class is also represented by the so-called plastic amalgams made since 1895–1896, and composed of silver, tin, zinc, and mercury. The high percentage silver amalgams, composed of silver, tin, copper, zinc, and mercury, may well represent a quinary amalgam. The terms binary, ternary, etc., have not gained in popularity with the profession in the last decade, although amalgams are in use representing each of the classes mentioned.

Buying and Keeping Alloys.—The question, "Which is the best alloy to buy?" is asked so often that it seems quite certain that the profession in this particular does not exercise the same judgment with which it selects other dental materials. It indicates quite clearly that there is yet much mystery surrounding the purchase of an alloy. When supplies the nature of which is not understood are required, the majority of the profession select them from a dealer who is believed to be reliable in this respect and who is known to be wholly reliable in others. As a rule, the larger supply houses are best equipped for

distributing uniform supplies of all kinds, and most likely to secure the services of competent men to manufacture their products. This is true in the manufacture of alloys, and should be used as a guide in their selection. Sometimes a good product comes from a dealer who is not well or favorably known, but this is the exception rather than the rule. Alloys and cements above all other products should be made and placed upon the market by competent chemists if the dentist is to be rewarded for his energies. The practising dentist should never attempt the manufacture of these products himself without first spending considerable time preparing himself by learning the peculiarities of these products with special apparatus built for the purpose.

Dentists, as a rule, are kept changing alloys by solicitous dealers who advance this or that quality of their alloy as a cure-all. For example, one dealer lauds his product as being superior because it contains more silver than a like article made by another. Another makes the same claims regarding the quantity of zinc in his product. Others advance the argument that the manner of cut of their manufacture has much to do with the success attending its use, and so it is with nearly every dealer. These arguments generally reward the dealer with sales because dentists, as a rule, are not sufficiently informed on the subject to enable them to judge the merits of the products themselves.

It is true that some of the best manufacturers differ as to what constitutes the "best alloy all things considered," but, as a rule, the difference of opinion is an honest one rather than an effort on the part of the producer to lessen the first cost of the article. This is shown by several leading dealers' products, which are found to contain from 65 per cent. of silver to 68 per cent. of silver, yet each will claim to have an alloy made after Dr. Black's plans, etc. The maker who uses 68 per cent. of silver knows that he obtains a little stronger filling, although he is conscious of the fact that it works a little harder and sets faster than one that contains only 65 per cent. of silver. On the other hand, he who uses 65 per cent. of silver knows that his product works a little easier and sets a little slower, although he is conscious that it is a little weaker. The maker who uses only 65 per cent. of silver probably considers it better to give the operator a little more time to work than to have a little stronger filling.

The same is true of the quantity of zinc now used in high percentage silver alloys. Some claim better and permanent light color in the mouth as a result of the use of a little more zinc, while others admit a loss in color as a result of its elimination, but claim to have a product more permanent in form. Neither disputes the other's claims, but each places greater stress upon the distinctive qualities of his product in contrast to those of his competitors. Thus it becomes a matter of judgment which quality is of most importance.

The leading dealers' high percentage silver alloys are all good, well-

made, uniform products, and except for the differences mentioned, they are nearly of equal value from a practical standpoint. Whether an alloy contains 65 or 68 per cent. of silver is not a guide to the quality of either. The same is generally true with the small quantities of zinc now used, although it is quite generally understood that zinc, while it improves color, facilitates change in volume subsequent to insertion when used in *any* quantity. Dentists *cannot* rely upon the quantity of *each* or *any* constituent as a guide to quality, although present knowledge of the subject confines the qualities of each constituent for the best alloys to the ranges stated on page 265. All things considered, the high percentage silver alloys are best, and should be chosen by dentists.

There are perhaps some places where the quick-setting properties make the use of these alloys questionable, but taken as a general rule, dentists soon learn to open up the orifice of the cavities and master the manipulation of these quick-setting, stiff-working products. When purchasing an alloy from a manufacturer who makes his product in both filings and shavings, the filings should be chosen. Shavings, as a rule, are not of the proper shape to permit their being dissolved readily in mercury. Not all manufacturers make their products "cut in two forms." As some dentists demand them, the maker sometimes can hold his trade by no other means than by supplying shavings to those who want them.

Some makers of high percentage silver alloys make only one grade of alloys as regards setting qualities, while others make their product in two or three grades. This, too, is usually done to catch trade, since most makers are aware that if more than one grade is supplied, some of the grades are imperfect products at the time of making. "Rapid setting," "slower setting," and "slow setting" are terms used to designate these products. They are the same in composition, but have not had the same amount of annealing. The accompanying chart shows the action of one of these alloys in the hands of the writer.

Formula—Ag 68, Sn 26.50, Cu 4.20, Zn 1.30 = 100.

Test number.	Time of annealing at 49° C.	Percentage of mercury.	Points of expansion.	Manner of setting.
1	0	63.00	19	Extremely rapid
2	1 day	59.00	7	Slower
3	2 days	58.00	3½	"
4	3 "	57.40	1½	"
5	5 "	57.25	¾	"
6	7 "	57.00	½	"
7	10 "	56.60	½	"
8	15 "	56.10	½	"
9	20 "	55.50	½	"
10	25 "	54.80	½	"

Tests Nos. 4 and 5 indicate about the manner of setting that most completed products would possess and would be marked by the maker as

"slow setting." Tests Nos. 2 and 3 indicate approximately the manner of setting that the products of some makers would possess and would be marked "rapid setting," "slower setting," etc. These products are but partially annealed, and may be regarded as incomplete. If the product of a manufacturer who makes several grades is to be used, the one marked "slow setting" should be chosen for immediate use. If the alloy is purchased in quantities, it is often advisable to select the "slow setting" for immediate use and some of the other grades for future use, because the "rapid-setting" alloys become "slow setting" by standing at ordinary temperatures.

Unfortunately, the date of manufacture of alloys is not stamped upon the package. This should be done, as the dentist has no protection against the purchase of old alloys which are unfit for use, other than the seller's honesty. As a rule, alloys which have stood in the market six months have deteriorated somewhat, and in a year they are not good for general use. Dentists should select their alloys with this in view. Buying in *large* quantities is not always safe, even if care has been exercised in selecting the product. Alloys should not be kept near a heater, in the sun during the summer months, or in an overheated room for any length of time. Alloy for immediate use must be at hand, but the remainder should be kept in a cool, dry place. Otherwise even a comparatively small stock of alloy will become so much annealed in a short time that it should not be used.

Discoloration of the Tooth Tissue.—This seems to occur much more rapidly with some amalgams than with others. It has been observed that the high percentage silver alloys and the so-called plastic alloys make amalgams which do not perceptibly discolor the tooth tissues if they are properly manipulated. Both of these classes of alloys remain quite light in color in almost all mouths, although the "plastic amalgams" are the lighter of the two. From this it would seem that the composition of the alloy from which the amalgam was made controlled the amount of discoloration which took place on an amalgam filling. Dr. Black and Dr. Adolph Witzel attribute the lack of discoloration of tooth tissue by some amalgams to the fact that the filling was imperfectly adapted or had decreased in volume, thus allowing moisture to penetrate between the walls of the tooth and filling. This is probably an important factor in this connection, but the composition of the alloy seems a greater one. Examination by the writer of a large number of mouths containing fillings made of alloys composed of approximately 49 per cent. of silver, 49 per cent. of tin, and 2 per cent. of zinc failed to reveal any evidence of discolored tooth tissue, and only *very* few fillings that were even darkened. A similar examination of a large number of fillings made from alloys composed of approximately 68 per cent. of silver, 26.5 per cent. of tin, 4.2 per cent of copper, and 1.3 per cent. of zinc that showed a majority was discolored somewhat, but no evidence of discolored

tooth tissue was found. Of course, an examination of this kind does not reveal the condition of the surface of the filling next to the tooth, except at the margins. It does, however, show the tendency of these alloys to discolor when exposed to the action of the saliva. Both of these alloys, it will be noted, contained zinc, and the lighter of the two contained no copper. Products similar to Flagg's 60 per cent. silver, 35 per cent. tin, and 5 per cent. copper alloy have been known to discolor quite markedly in most mouths, and have been the cause of much discolored tooth tissue. Since no such combination known is free from shrinkage, it is impossible to say whether such discolored tooth tissue was caused by the shrinkage or the character of the amalgam, or both. It is probable that amalgams similar to that of Dr. Flagg's, which do not contain zinc, will cause discolored tooth tissue if used at a stage where shrinkage is taking place or if they are imperfectly adapted.

Much has been claimed for the presence of zinc in even small quantities in alloys used for dental amalgams. Just how the profession will consider it in the future cannot be definitely stated, since most of the writings on the subject agree that it is the constituent which facilitates change in volume subsequent to insertion. The same writers agree, however, that it prevents discoloration of the amalgam as well as of the adjacent tooth tissue.

Elimination of zinc from high percentage alloys would leave a product composed of silver, tin, and copper, the same as Dr. Flagg's, although the percentages would be slightly changed. Dr. Black states[1] that "0.5 per cent. of zinc is inadmissible for the reason that the amalgam will continue to change bulk very slowly for five years or longer." If his latest judgment in this respect were to be carried out by the makers of these products, there would not be much difference in color between alloys made after his plans and those of Dr. Flagg, although they would probably have the advantage of being free from shrinkage.

It is probable that the makers of amalgams will endeavor to incorporate the zinc in such a manner as to keep the amalgams from moving after insertion, rather than permit a reduction in color and a step backward. Plans have already been advanced by one or two makers of alloys whereby the zinc is incorporated into the amalgam almost independently of the other constituents. Dr. Black states that this action of zinc in the change in bulk was so subtle that it was not at first discovered, and suggests its elimination from these products. It is doubtful whether the profession will agree to return to amalgams of a darker color, even if there is some change in bulk. With the promise of new methods of incorporating zinc and other products it is questionable whether this will be necessary.

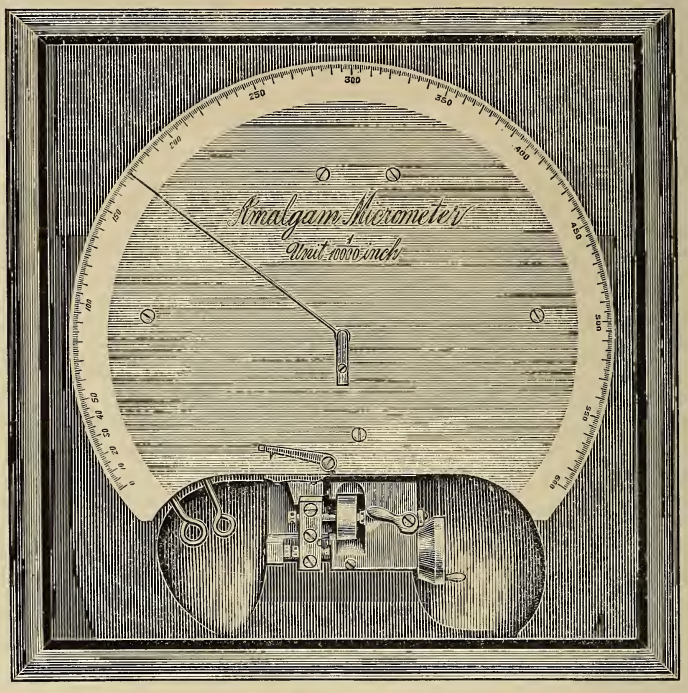
Alloys which have not been cut too coarse, and have been worked

[1] Operative Dentistry, vol. ii, 312.

thoroughly by the dentist to a relatively complete solution of the alloy in the mercury, have long given enough service to warrant their continued use. The dentist can prevent much of the change in bulk by his selection of alloy and manipulation of it.

Some claim that amalgams may discolor the dentin by a percolation into the dentinal tubules of salts formed when amalgam was placed in contact with the open ends of these tubules, the filling remaining water tight. The writer has had his attention called to this by two or three practitioners who are using copper amalgam in an occasional remote cavity. Amalgam which has discolored usually takes on a

Fig 305

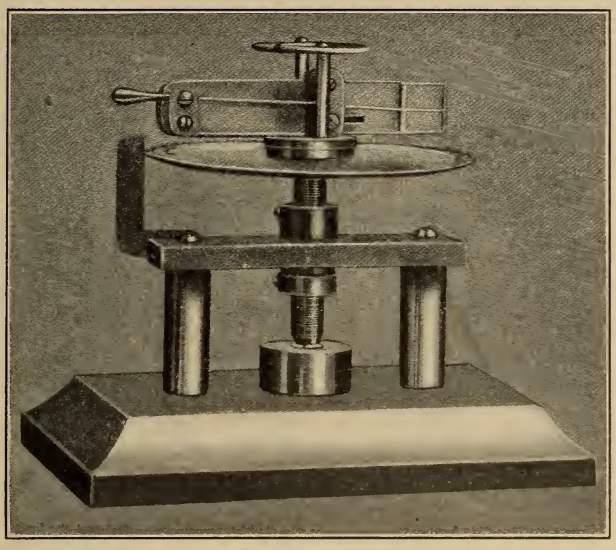


Black's micrometer.

blackish hue. Tooth tissue, on the other hand, may appear brown, black, or green, the latter being the case when a silver-tin alloy containing a large percentage of copper is used. The extent of the discoloration of tooth tissue depends, apart from the composition of the alloy, largely upon the access of the saliva to the surface of the filling next to the cavity walls and upon the size of the dentinal tubules. If the tubules are quite small or are obliterated, there will not be an extensive discoloration. If the amalgam is one which discolors readily and there is opportunity for the saliva to penetrate between the cavity wall and the filling, rapid and extensive discoloration will occur if the dentin is capable of being pene-

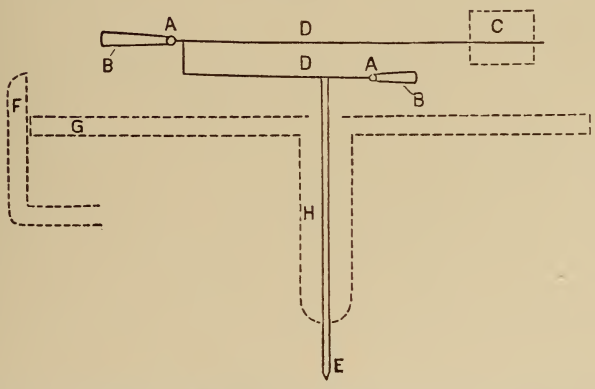
trated. On the other hand, if there is very little access for the saliva the discoloration will be slow and less extensive.

FIG. 306



Amalgam micrometer.

FIG. 307



A A represent two jewelled bearings from which swing the two levers *D D*. These two levers are counterbalanced by the two adjustable counterweights *B B*, which enable one to bring the instrument into contact with the filling at *E* with a minimum amount of pressure upon the filling. As these levers are *small* steel needles, this amount is very small when the counterweights are adjusted, and at the same time allows one to use very long levers, which is a decided advantage. *C* represents a small mirror in front of which swings the longer lever *D*, which must coincide with the fine line across the mirror every time a reading is taken at the vertical bar *F*. This vertical bar is ground to a knife-edge, so that it easily falls upon or between the graduations on the disk *G*. The bar also contains graduations which are the same distance apart as the threads on the micrometer screw *H*, thus enabling one to tell at a glance how many turns the screw has made.

Measuring Contraction and Expansion.—Doubt has been expressed in regard to the accuracy of a micrometer for determining contraction and

expansion. Those who have had experience in determining densities by the specific gravity method are usually skeptical about the accuracy of the tests for the alloys if the maker has used a micrometer. The micrometer, however, has gained in popularity since alloys have been made which have practically only one movement, viz., expansion. The Wedelstaedt steel test-tube, as modified by the writer, shown in Fig. 297 has gained in popularity simultaneously with the micrometer as a receptacle for making test fillings. These receptacles are used in connection with micrometers of various designs. Fig. 305 shows the one designed by Dr. Black, Figs. 306 and 307 show the one designed by the writer. A casual observation will show that these instruments measure the upward flow of metal caused by an amalgam which expands, but this is not the case when the amalgam contracts, as contraction tends to take place in the manner shown in Fig. 308. The micrometer, a much more convenient means of determining expansion than the specific gravity method, is usually employed for this purpose, although it is considered of little value in determining contraction. While the specific

FIG. 308

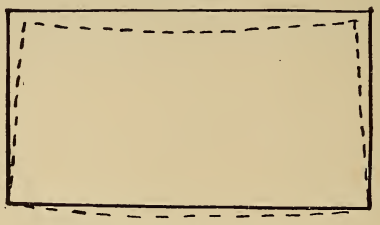


Diagram of amalgam shrinkage.

gravity method is considered the most accurate means of determining both contraction and expansion, its results do not always coincide with those taken on a micrometer for expansion. An amalgam which shows an expansion on the micrometer may show a contraction when tested by the specific gravity method. This is usually the case when alloys are coarsely cut and are not well broken down in the mercury during amalgamation. Such an amalgam filling which is smooth at the time of making becomes somewhat porous within a few hours, owing to the absorption of mercury from the interstices on the surface to the interior of the filling. The specific gravity method will measure these interstices and show a contraction, while the micrometer giving only a linear measurement may show that the linear dimensions have actually increased.

CEMENTS

The cements obtainable for dental purposes consist chiefly of the zinc oxychlorids and three classes of oxyphosphates. The oxysulphate has been used some in the past, but hardly deserves consideration any

longer. The oxychlorid is formed by the combination of highly calcined oxid of zinc and zinc chlorid. The oxyphosphates are formed by the combination of a more or less modified phosphoric acid with one or more oxids of metals.

Zinc chlorid + . . Oxid of zinc = Oxychlorids.

Phosphoric acid + . .
- Oxid of zinc = Basic zinc phosphates { Alkaline. / Non-alkaline.
- Oxid of copper = Oxyphosphate of copper.
- Oxids of { Beryllium. / Silicia = Silicate cements. / Aluminum. / Calcium.

The foregoing diagram of the different cements shows at a glance the classification of the substances which form these compounds. For example, the first compound is composed of zinc chlorid and an oxid of a metal.

The three classes of oxyphosphates are composed of oxids of metals with phosphoric acid. The zinc oxychlorids have been used for a variety of purposes, but have been almost displaced by newer compounds known as improved oxyphosphates. When calcined zinc oxid is combined with zinc chlorid, a very white basic zinc salt is formed which sets quite promptly, although its physical properties which meet the requirements of dentistry are few in number.

Recent improvements in the three classes of oxyphosphates have placed them where they meet many of the long sought for qualities of this material. These compounds resemble amalgams in that the powder portion is usually in excess in the mass after it has set. Dr. Ames has "somewhat figuratively" applied the term "basic" to these compounds, although it is hardly in keeping with chemical nomenclature.

When calcined zinc oxid is brought into contact with phosphoric acid a part of the oxid goes into solution, but as a putty-like consistency is approached, the mass consists of many times one equivalent of the base for each one of the acid. The oxyphosphates (also the oxychlorids) assume the aspect of concrete at the time of setting by containing a cementing medium of zinc phosphate holding together zinc oxid granules.

The first class of oxyphosphates, known as the basic zinc phosphates, has been divided into two classes according to the modifiers in solution in the phosphoric acid, one known as alkaline and the other as non-alkaline. The liquid portion of the alkaline cements differs from that of the non-alkaline in the quantity of sodium phosphate it contains. When metaphosphoric acid is combined with sodium phosphate the former takes on a smooth, glassy consistency, and is known as glacial phosphoric acid, although, as suggested by Dr. Ames, it is in reality orthophosphoric acid and orthophosphate of sodium, as a result of effecting the combination in the presence of water. The addition of this sodium salt aids very materially in handling and working the acid,

but it makes a soft, porous cementing medium. Other metals than the alkaline group have been added to the phosphoric acid, principally in the form of phosphates, to form an improved product much less porous than the alkaline cement. Not all of the sodium has been discarded as some analyses show. Some of the good qualities of the sodium have been retained apparently, by substituting such metals as magnesium, aluminum, silver, zinc, and copper for a portion of the sodium. The powder portion of the basic zinc phosphates contains other materials than zinc oxid, some of which are added for the purpose of pigmenting and some for the improvement of the integrity of the cementing medium. Oftentimes these materials found as modifiers in the powder portion are partially or wholly insoluble in the liquid portion. In this case, other things being equal, the cement mass would resist attrition somewhat better.

The presence of partially or wholly insoluble substances in the powder portion of these cements cannot, however, be taken as a guide to the property of resistance to attrition. Like sodium phosphate, they can hardly be dispensed with entirely, except in cements used for crown-, bridge- and inlay-work, and then their elimination is questionable. Of such substances the oxids of aluminum and silicon are notable.

Substances which are known to hasten or retard the setting properties of these cements are added in small quantities to the powder as well as to the liquid portions. Among such materials are calcium oxid and sodium phosphate, the former hastening and the latter retarding the setting property. The properties may be modified widely by the treatment given the different oxids, especially zinc oxid. Zinc oxid may be prepared by heating zinc hydroxid, the loss of water converting it into the oxid. The same compound may be prepared by igniting metallic zinc in air. Zinc oxid which has been heated comparatively little will make a soft powder and a sticky cement, while if the zinc oxid is calcined a great deal it is flint-like and makes a less sticky cement. This is taken into consideration in the production of the basic zinc cements, some products appearing to contain two or three grades, as regards the amount of calcining.

The second class of oxyphosphates, known as oxyphosphates of copper, are similar in construction to the basic zinc phosphates, and what has been said of modifiers in the powder and liquid portions of the basic zinc compounds applies equally to this class. Generally speaking, they differ from the basic zinc compounds by having oxid of copper for the base of the powder instead of oxid of zinc.

The third class of oxyphosphates, known as silicate cements, differ from the basic zinc compounds, by being composed of oxids of other metals than zinc, with phosphoric acid. Among such metals may be mentioned beryllium, calcium, aluminum, and silicon. Since even less work has been done with this class of cements than with the other

classes it is uncertain what the liquid or powder portion will eventually be. It is claimed that a certain well-known product has aluminum phosphate in large quantities and zinc phosphate in small quantities in its phosphoric acid. H. Carlton Smith stated in a paper before the American Academy of Dental Science at Boston, February 7, 1906, that he believed these claims were faithfully carried out. During the last year the writer has examined several of these products, and found the one referred to by Dr. Smith very constant in composition and to contain the ingredients claimed by its promotors.

Some other silicate cements have appeared to differ somewhat from the one mentioned, both in the liquid and the powder portions, the greatest difference being in the quantity of beryllium. While in general terms the base of nearly all cement liquids is phosphoric acid, and the base or foundation of the powder portion is an oxid of a metal, it is no assurance that the compounds are not very complex bodies involving intricate chemistry. The virtue of almost any of these compounds is so dependent upon some particular modifiers of oxid of zinc and phosphoric acid that the use of other liquids and powder than those intended by the manufacturer means certain disappointment to the user. For this reason it is never safe to substitute for either the liquid or powder of a given make the liquid or powder of another make. This is also true with different classes of oxyphosphates from the same maker.

A given phosphoric acid of a given concentration will combine with certain of these metallic oxids and produce a compound of a certain insolubility, possessed of certain working qualities and capable of a minimum of change in volume. If phosphoric acids of other concentrations or phosphoric acid containing the phosphates of other metals be substituted a change of properties very detrimental to the product is likely to occur.

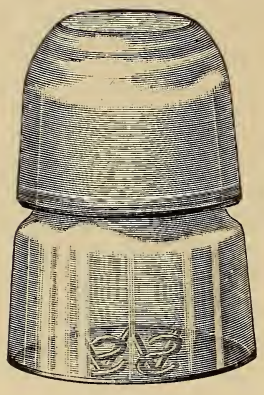
Attention may again be directed to the fact that phosphoric acid for certain of these cements contains non-alkaline metallic phosphates almost to the point of saturation; this is necessary in order to bring about the desired qualities of the cement. Certain of the newer products are compounded in this way. In addition, some of the slow-setting cement liquids contain the alkaline phosphate of sodium, which partially neutralizes this tri-basic acid, assuming that orthophosphoric acid is used. Such a phosphoric acid is loaded to the fullest extent with modifiers, and is apt to crystallize on standing. To avoid this crystallization, Dr. Ames conceived the idea of furnishing his cements compounded for quick setting and furnishes extra some of the acid prepared with phosphates, to retard the setting and add a little to the adhesive properties, etc. This he calls "flux."

Some interesting phenomena usually occur in the "loading" of phosphoric acid and in neutralizing it with sodium salts. Orthophosphoric acid is theoretically a tri-basic acid, and forms mono-basic, di-basic, and

tri-basic salts, the first two being acid to litmus and the latter alkaline with sodium. It may be seen, however, with the aid of litmus, that sodium carbonate of varying dilutions will bring about the transition from acid to alkali so gradually that no definite quantity can be said to neutralize an aqueous solution of phosphoric acid. The following equation indicates the amount of sodium carbonate that would be expected to neutralize phosphoric acid: $H_3PO_4 + 3NaOH = Na_3PO_4 + 3H_2O$; experiment, however, shows that approximately one-half the quantity indicated by the formula is all that is necessary to bring about an alkaline test with litmus.

Another phenomenon accompanies the use of varying dilutions of sodium carbonate. After a given quantity of sodium carbonate has been ascertained which will neutralize phosphoric acid it is found necessary to alter this, with changes in temperature and changes in dilution of the sodium salt. These phenomena appear to be due to the difference in dissociation of the three hydrogens of phosphoric acid. Ostwald has stated that not only does the dissociation $H_3PO_4 = H + H_2PO_4$ occur comparatively easily, but in measurable amount. The further dissociation $H_2PO_4 = H + HPO_4$ he states takes place only in a very slight degree, and the third dissociation, $HPO_4 = H + PO_4$, is exceedingly slight. This seems to account for these phenomena reasonably well when phosphoric acid and sodium carbonate are used, but when phosphoric acid is loaded to, or nearly to, saturation with one or more modifiers, and the setting qualities of a cement made from it seem to demand the introduction of alkaline phosphate, certain phenomena appear which are less easily explained. It would seem that the liquid portion of cements thus compounded would rarely ever withstand the vicissitudes to which they are subjected.

Fig. 309



It is found that if certain precautions are observed, most cement liquids stand for a time without crystallization. Any portion of the cement liquid that is subjected to the changes in humidity of most rooms that occurs with the change from natural to artificial heat will have a strong tendency to crystallize. When crystallization has once begun, it tends to spread to any uncrystallized portion and upon newly made liquid of the same composition. When the ordinary bottle, either with rubber or glass stopper, is used, there is, even with care, the chance of leaving some of the liquid exposed to the air around the neck of the bottle. This may be avoided somewhat by transferring the liquid from the container, as it is purchased, to the telescoping cap bottle (Fig. 309). This requires less care to prevent some of the liquid

remaining around the neck exposed to the air. A further precaution is to be observed when removing the liquid from the bottle. Only a *perfectly clean* glass dropper should be used. A non-corrodible spatula may safely be used if it has not previously been employed to remove powder from the bottle, and is free from any other foreign substance which by combination with the acid would interfere with the equilibrium of composition in the liquid.

Several modifications may be made in the setting qualities and strength of a cement by the physical condition of the powder portion. A given coarse powder mixed with a phosphoric acid solution may be slow setting; the same powder when reduced to a finer state may be rapid setting because of the increased surface of the zinc oxid presented for action to the phosphoric acid solution. An analogous process occurs in most plastics, except some of the alloys, which would also act this way were it not for the annealing which takes place more rapidly with the finer cut alloy. Some cements which are supposed to be alike will act differently, on account of this difference in the fineness or coarseness of the powder portion. This is, obviously, analogous to other plastics. Each combination has *only* a given coarseness and fineness which will yield given physical characteristics. The strength of cements may be modified by the size of the granules of their powder portion. In some cements the adhesive property seems to have been developed to the slight detriment of strength, such cements being intended for setting inlays, etc. The powder portion of these inlay cements is often much finer than the powder of the same cement used for fillings. There appears to be a limit, however, to the fineness of powders, strength falling off if they are extremely fine. Strength likewise decreases if the powder is very coarse.

Another modification of these cements may result from an exposure of the powder portion to the atmosphere of the room. The oxids will hydrate and absorb carbon dioxid and become hydrated carbonates of the metals of which they are composed.

It is doubtful whether the products of the best manufacturers contain impurities which appreciably modify the behavior of these cements. Until recently, however, impurities have not been watched for with as much care, and both liquid and powder have been subject to them. Much of the irritation to the pulp from cements has been attributed to the presence of arsenic as an impurity. Chemical investigation has proved that while arsenic is invariably present as an impurity in oxid of zinc it is in the form of insoluble zinc arsenite and inert to the pulp tissue. Impurities have been found in the liquid of the cheaper cements, but the liquids of the better products contain little or nothing that was not intentionally placed there by the manufacturer.

A commerical glacial phosphoric acid has a somewhat variable composition. It is the metaphosphoric acid containing some sodium phosphate, and because of its hygroscopic properties a varying amount of

water, which slowly converts the metaphosphoric acid to orthophosphoric acid. The liquids of the better cements, however, are not commerical products. They contain, very often, a number of ingredients in small quantities, but the effect of each ingredient upon the integrity of the cement mass, its solubility, its volumetric change during setting, and rapidity of setting, is known. A bottle of carefully prepared cement liquid may, after standing for some time, appear somewhat turbid toward the bottom of the bottle and appeared contaminated with impurities in some or all of the constituents. This is often observed when a portion of the bottle of liquid has been used. Such phenomena are usually due to the formation of layers of different densities, and the residue of a bottle of liquid almost always has a higher specific gravity than the liquid formerly had. Such liquids do not indicate the presence of impurities as much as the attempt on the part of the maker to combine the properties of a number of substances, the result being a liquid which will not withstand the vicissitudes to which it is subjected.

Properties and Uses of Cements.—The better products are tested for volumetric change at and subsequent to insertion, in the same manner and with the same instruments as alloys. The Wedelstaedt steel test-tube is used as a matrix to retain the cement, and a micrometer such as shown in Fig. 306 will permit subjecting the filling to a water bath at any stage during the setting by placing the micrometer in a small container at the time of taking the first reading and allowing water to flow into the container at the desired time.

It is very esential that cements be tested both dry and wet; with alloys no action with the water will modify change in volume or strength. Not so with the cements. A cement which will shrink markedly when dry may expand very much if subjected to a water bath during the earlier stages of the setting. Like alloys, the best cements expand slightly. The expansion of the cements at and subsequent to insertion may be modified by at least two factors, viz., the stiffness of the mix and the time that moisture is allowed access to the cement.

If moisture is kept from a cement intended to be hydraulic there may be no expansion, while if it is subjected to moisture early in the setting it may expand several points. With a stiff mix, as used for fillings, less expansion is likely than when less powder is incorporated and the consistency appears about midway between that of a cement mixed for cementing inlays, bands, etc., and that mixed for a filling. The creamy mix, as a rule, gives the greatest expansion, although there must not be too little powder, as is often the case when mixing for inlays, etc., or there will be a slight shrinkage. The strength of the cements is modified to even a greater degree by the manner of mixing than is the strength of alloys. Almost any strength may be obtained from 300 pounds to 1500 pounds on a cylinder $\frac{1}{4}$ inch high and $\frac{1}{4}$ inch in diameter. As in the case of alloys there is no definite time during which

cements will resist a given force. Some of the present cements, however, appear to change less in strength than most alloys do if they are kept from the oral media. The union between many of the oxids and modified phosphoric acid solutions is effected much more energetically, and in consequence is less likely to result in the menstruum acting upon the solid under ordinary conditions. It is nearly impossible, however, to obtain a perfect chemical product from the cements under the manipulation given them by dentists.

Attention has already been called to the excess of zinc oxid granules which is always present when cement is mixed for a filling. When it is mixed for cementing bands, inlays, etc., this is not always true. When cements are subjected to the oral media the integrity of the cement mass usually suffers, especially in the case of the basic zinc phosphates and oxyphosphate of copper, both of which are subject to the solvent action of basic and acid products of the mouth. The presence of lactic acid in the mouth due to the process of fermentation and its action upon the basic zinc phosphates and oxyphosphates of copper are well known. Ammonia water also dissolves some of the oxids, notably zinc oxid, and as it is doubtful if a basic zinc phosphate is ever composed of the exact combining weights to form a basic phosphate, it is not unreasonable to suppose that some of the basic phosphate cements will disintegrate as a result of this action. Ammonia infrequently occurs as such in the mouth, but the ammonium salt in the form of chlorid does, and its action upon the basic oxyphosphates much resembles that of ammonia, although it is slower.

Much is claimed for the insolubility of the newer products known as silicate cements, but their origin is so recent and, with one or two exceptions, they are so changeable in composition that few data of a practical nature are obtainable. Laboratory tests, however, are encouraging, but before being accepted they must be verified by practical tests. Dr. Joseph Head[1] has pointed out that any test which might be applied in the laboratory is only a guide to the solubility of cements in different mouths. He has shown that a 1 to 500 lactic acid and water solution will turn tooth enamel white in one-half hour, while a 1 to 500 lactic acid and saliva may not attack it appreciably for weeks, and yet the latter solution may turn blue litmus brilliantly red and possess an acid taste. This phenomenon he attributes to the restraining power of saliva upon lactic as well as other acids. He also points out that this property of the saliva varies in different individuals and in the same individuals at different intervals.

Dr. Kirk[2] has pointed out that mucin is probably the protective element in the saliva which prevents the action of highly dilute acids upon the teeth. He has also called attention to a quite analogous

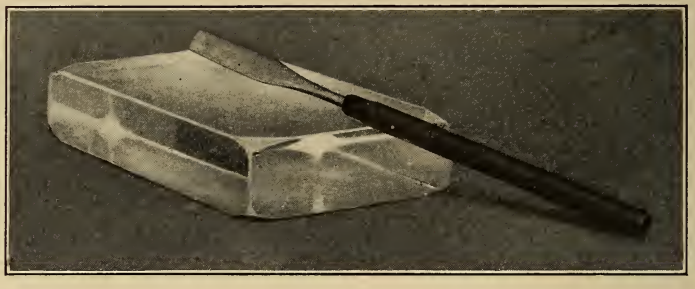
[1] Dental Cosmos, August, 1908.

[2] Ibid., vol. lii, p. 735.

phenomenon,[1] in which he shows that both acid and basic sodium phosphate may exist in the same saliva and not be neutralized by each other. Thus, it seems that the solubility of the cements depends more upon the *condition of the saliva* than the mere presence of any solvent coming from the saliva, products of fermentation, or the food.

The uses to which the basic zinc phosphates may be put are about as variable as are the cases requiring the services of the dentist. The popularity of the inlay method of filling teeth has increased its usefulness in retaining fillings. The increased amount of orthodontia done from year to year has demanded more of this material for the retention of bands, etc. Its use as a filling, however, is probably as limited as ever, it being regarded as a temporary filling in every sense. Many specimens have been exhibited in which these cements have served as a filling for several years, but such cases are the exception rather than the rule. These cements are valuable in temporary operations on the teeth of adults and children. They are indispensable in retaining fixed bridge-work and crowns and are invaluable in eliminating undercuts and forming the base of cavities for all kinds of fillings.

Fig. 310

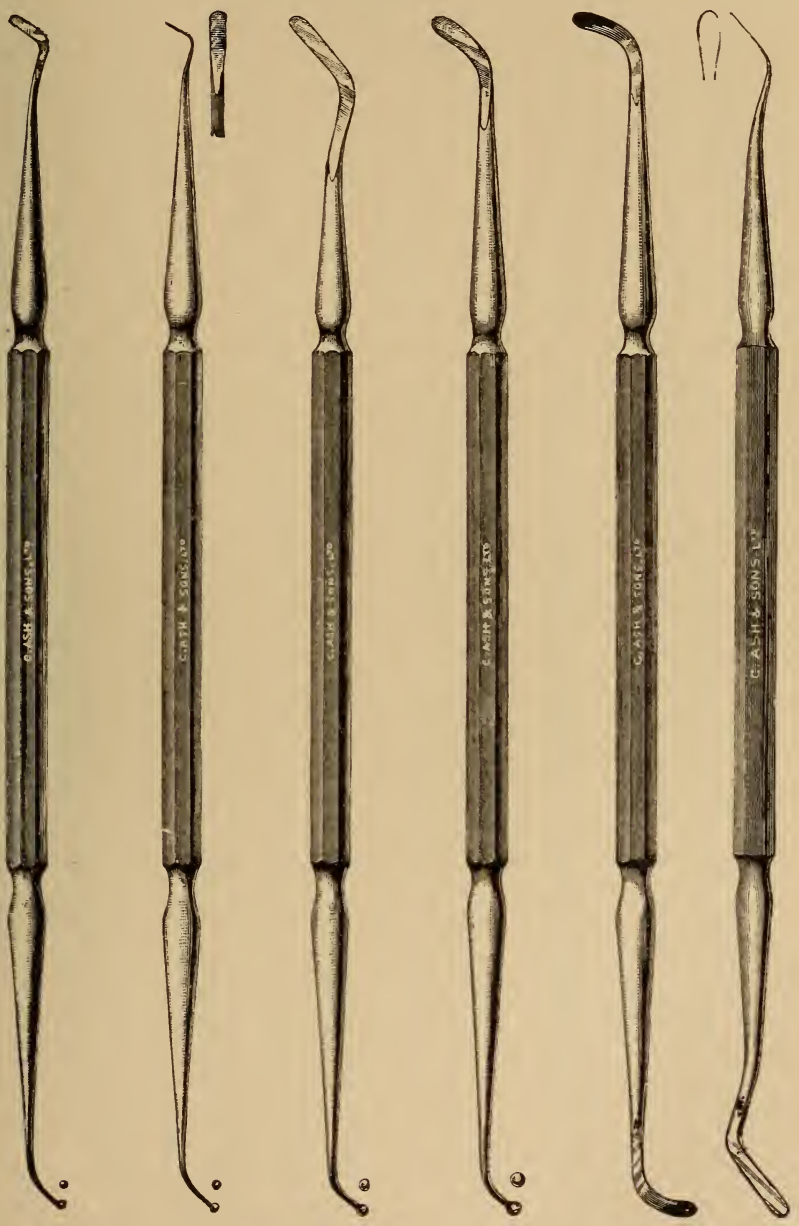


The oxyphosphate of copper cements may be used like the basic zinc phosphates, although they are more applicable to the teeth of children and of such adults as require the salutary effect of the copper salts. These cements are much more bland than either the basic zinc phosphates or the silicate cements. When placed near a pulp or the peridental tissues these copper salts seem to exert a beneficial rather than a destructive influence, as also in the pulp chambers and canals of deciduous teeth. The silicate cements have not been in use long enough to enable the profession to judge of their properties although they seem to make very good fillings. They are almost devoid of adhesiveness, which excludes them from use for retaining bands, inlays, crowns, bridges, etc. They are much more translucent, and much less soluble than any other cement used in dentistry.

[1] Dental Cosmos, April, 1907.

Mixing of Cement.—To mix the powder and liquid properly they should be placed upon a large glass slab which is attached to the cabinet

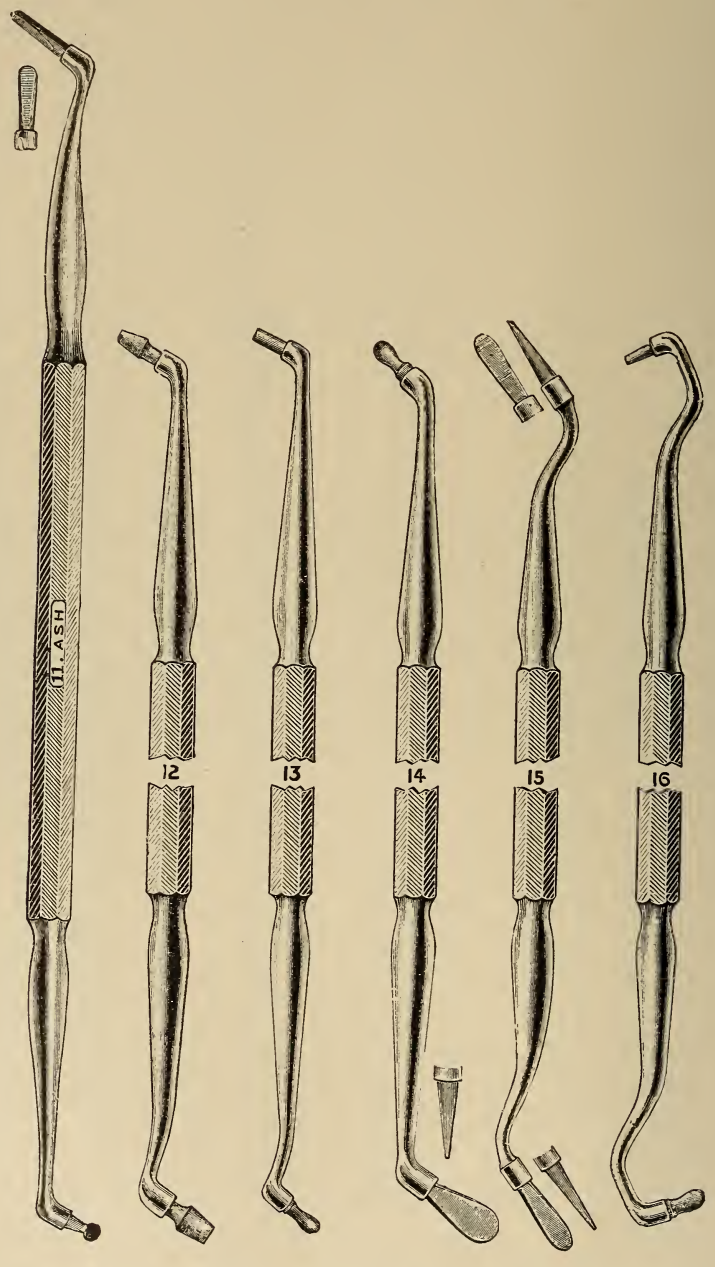
Fig. 311



or a thick one which can be easily grasped with the hand and held still during the mixing (Fig. 310). The powder and liquid should be

placed some distance apart, so that a small amount of powder can be cut into the amount of liquid thought to be necessary for the operation, with a large iridio-platinum or good grade German silver spatula, if the

Fig. 312



Ash's agate-ended plastic instruments for inserting, packing, and polishing silicate cement.

cement be a basic zinc phosphate or oxyphosphate of copper. If the cement be a silicate cement and the operation require the translucency obtainable with these bodies, a bone or agate spatula should be used, but in no case should a steel spatula be employed. Iridioplatinum is probably the best material for a spatula in operations where a slight modification of color is not objectionable, although it is doubtful if there is sufficient abrasion from this kind of spatula appreciably to modify the color of the silicate cements. The objection to most agate and bone spatulas is their shape, which will not enable the operator to form a thorough mix in the time at his disposal before the cement begins to set. The most practical spatula for the basic zinc phosphates and oxyphosphates of copper seems to be one of good German silver. It is not attacked energetically by the phosphoric acid solution and is not abraded sufficiently to be injurious to an appreciable extent to these cements. The reverse is true when a steel spatula is used, as phosphate of iron usually is detrimental.

Each addition of powder should be cut into the liquid in a clean manner and mixed until a thorough incorporation of the two is in evidence before another addition is made. This should be continued until the desired consistency is obtained. For retaining inlays, bands, crowns, etc., the mixture must be of a consistency to flow quite freely. For fillings the mass should be of a putty-like consistency, which can be packed. The demands of the dentist are so varied that the consistency of the mass before it is set determines the amount of powder to be added to a given amount of liquid. No definite proportions can be given which will meet the requirements of all cases. The silicate cements and oxyphosphates of copper employed principally for fillings permit of more definite proportions than the basic zinc phosphates which are used for a variety of purposes. There is one exception to mixing cements to a putty-like consistency for fillings, viz., in the use of the oxyphosphates of copper. These cements appear to develop a greater density and to disintegrate less easily when mixed to a creamy consistency, although in this condition they are not always as easily inserted into a cavity. It is often necessary to vary the consistency with the temperature of the room and that of the mixing slab. Since heat facilitates chemical change, it is often necessary to make the mix a little thinner in hot weather or if the slab is quite warm.

All instruments used in mixing cements should be scrupulously clean. Foreign substances which would not injure an alloy, might work marked injury to a cement. The presence of moisture before the cement has been placed may work an injury to the quality of the cement formed, but with the newer products it is often desirable to allow moisture to have access to the fillings after it has been placed. This applies obviously only to the cements compounded for this purpose and designated as hydraulic cements.

Nearly all basic zinc phosphates and oxyphosphates of copper in use at present are compounded so as to act properly when subjected to moisture almost immediately after being placed. A few of the older products, however, must be protected from moisture for hours after being placed. This may be done by covering them with wax or paraffin. The silicate cements are very susceptible to moisture. A mere trace seems to injure them markedly, even after they have been placed several minutes. These cements should be inserted in the *entire absence of moisture* and covered for several hours with some protective material. Waxes and paraffins are the principal substances adopted for this purpose.

The writer has had the greatest success with the sticky wax made after the formula of Dr. Fred. A. Peeso, consisting of pure white wax, 16 parts; white resin (colophony), powdered, 3 parts; gum dammar, powdered, 3 parts. It is light in color and extremely adhesive, the latter quality being of the greatest importance in protecting the filling from moisture.

What has been said of packing alloys is also true of the cements, with the exception of the oxyphosphates of copper, some of which are best mixed to a creamy consistency and often most readily inserted without a matrix. The basic zinc phosphates and silicate cements are best inserted with a matrix if the cavity be a proximal or proximo-occlusal one. All cavities which are not four walled should be converted into such by the use of the matrix.

The same matrices used for alloys may be used with the basic zinc phosphates, the majority being thin steel. Unlike the steel spatula, the steel matrix does little or no harm because there is little abrasion, and, besides, the acidity of the liquid has been lessened by the basic powder portion. German silver and copper may also be used for matrices with the basic zinc phosphates and oxyphosphates of copper, but not always with the silicate cements. They should usually be inserted with a celluloid matrix. If there is slight or no abrasion between the silicate cement and metal matrix, little or no harm results; but if some abrasion occurs, discoloration and injury to the integrity of the cement are apt to take place. The basic zinc phosphates and oxyphosphates of copper may be packed and trimmed with the same instruments as those used for alloys, although it is better not to use instruments with serrations.

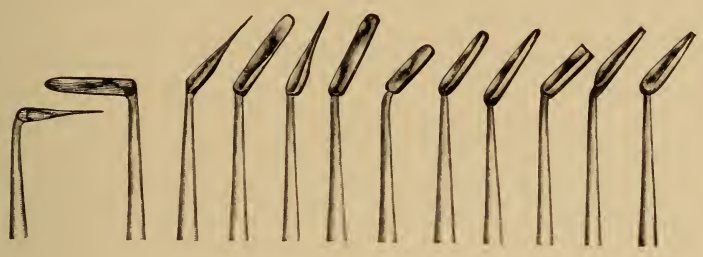
Fig. 311 shows very desirable forms of instruments for use in handling these cements. One or two of the ball-shaped instruments should be ground so that only one-half of the ball is left, to make them flat instead of round packing instruments. An amalgam plugger or two may have the serrations ground off, leaving them flat and smooth so that the cement will not adhere so tightly to the packing surface of the instrument. The silicate cements may be packed and trimmed with steel instruments if care is exercised not to rub the instrument over the cement. The makers of these products generally condemn the use of steel instru-

ments, because in unskilled hands the result is a discolored filling. Agate, bone, or tortoise-shell instruments (Figs. 312 and 313) are invariably advocated, although according to the general judgment they are not delicate enough to permit the technique necessary for good results. If the packing is done with as little rubbing as possible, steel instruments may be used with little danger of discoloration.

The same is true in trimming. The instruments should be sharp enough to avoid unnecessary friction. The agate and bone instruments advocated by their makers are practical for large cavities where the margins extend well from the proximate surfaces of the teeth, and for occlusal, buccal, and lingual cavities.

The cements may be finished with paper or cloth strips or disks as soon as they have hardened, varying with different cements, the manner of mixing, and the presence or absence of water.

Fig. 313



Tortoise-shell points to be mounted on any instrument handle.

Care should be exercised in the selection of strips or disks for use on the silicate cements. If the abrasive material on the strip or disk be dark colored there is liable to be a surface discoloration, due to the incorporation of the abrasive material into the surface of the filling.

Steel burnishers used to finish metal fillings should not be used to finish any cement filling after the cement has hardened sufficiently to abrade them while rubbing them over the filling. More importance is attached to the finish given the silicate cements than upon the basic zinc phosphates or oxyphosphates of copper. Owing to the solubility of the two latter classes a finish will last but a short time.

It is claimed by some that a polished surface on the better silicate cements will last longer and aid materially in preventing an alteration of the pigments in them. This, however, is a recent observation, and has not been verified by a sufficient number to warrant the acceptance of this theory. Undoubtedly a polished surface will more closely approximate the luster of the enamel and make a more finished piece of work, but if the stability of the pigments is dependent upon a polished surface, even to a slight degree, there are certain to be discolored fillings.

GUTTA-PERCHA

The gutta-percha of commerce is the concrete juice of the Isonandra gutta, an evergreen tree of the order of Sapotaceæ, found chiefly in the Malay peninsula and archipelago. The juice is secured by tapping the cambium layer of the tree and catching the juice as it exudes. The juice thus obtained undergoes many processes for purification before it is formed into sheets as seen in commerce (see works on Gutta-percha), and several more before it appears in the market for dental purposes.

"The purified gutta-percha probably consists of a hydrocarbon (pure gutta) having the formula $C_{10}H_{16}$; albane, $C_{40}H_{64}O_3$; and a variable compound named guttane. Pure gutta possesses all the good qualities of gutta-percha in a much enhanced degree, becoming soft and plastic on heating and hard and tenacious on cooling without being in the least brittle. The resins seem to be simply accessory components which have a decidedly detrimental effect when they preponderate. Water, wood fibers, bark, sand, etc., occur as mechanical impurities of gutta-percha." (Obach.)

It will be seen that gutta-percha resembles rubber in composition, since it consists chiefly of a hydrocarbid, in which the two elements, carbon and hydrogen, are present in similar proportions. Gutta-percha resembles rubber also in its origin, both coming from the milky juice of certain trees, although some claim a superior quality of gutta is obtained by processes of extraction from the dried leaves and buds. Apart from these similarities, the two substances are not so very similar. Rubber is a very elastic body, *i. e.*, it is capable of returning to its original form when a mechanical force causes it to undergo a change. Gutta-percha, on the other hand, has a tendency to preserve the change in form produced on it by the action of similar forces. Rubber containing no sulphur softens under heat, as does gutta-percha, but preserves its elasticity if the heat be kept within certain limits; beyond a definite degree of heat its physical and chemical properties are altered. Gutta-percha, on the contrary, under heat which does not exceed 110° C., is very plastic and malleable and preserves on cooling the appearance and shapes which have been given to it while in the plastic state. Several other differences between the two exist, such as the action of light, moisture, and air, the action of sulphur on the two, their non-conducting properties, etc., though the principal difference in this connection is the one in their elasticity.

Because gutta-percha preserved the shape given to it exceedingly well for a material of its nature, it was introduced as a filling material into dental practice, according to Dr. Kirk, about the year 1847. Since that time several secret preparations have been introduced, all of which

have probably been gutta-percha to which other substances have been added for the purpose of changing the physical properties by improving the desirable ones and masking or destroying the undesirable ones. One of the first to appear was by Dr. Hill, which received his name. Several analyses of Hill's stopping have been given, all of which are probably untrustworthy. Dr. Herman Prinz,[1] however, gives the formula of Hill's stopping as: Feldspar, 1 part; quartz, 1 part; quicklime, 2 parts; gutta-percha base-plate, a sufficient quantity to make a stiff mass.

Dr. Prinz does not give his authority for this formula, although it would seem that if both feldspar and quartz were added it would be done empirically. Dr. Kirk has said: "It subserved so useful a purpose that it received the tribute of wide imitation; in fact, the white gutta-percha preparations of the present day had their foundation in this imitation." Undoubtedly the present gutta-perchas and their modifications have gradually developed from this preparation, in the same manner that other filling materials have become very complex compounds as a result of years of study. The gutta-perchas for dental use are divided into three classes according to the temperature of softening: "Low heat," softening below 200° F.; "Medium heat," becoming plastic at 200° to 212° F.; "High heat," 210° to 220° F. The three kinds are often numbered to distinguish them from each other, one manufacturer assigning No. $6\frac{1}{2}$ to the low heat, No. $7\frac{1}{2}$ to the medium heat, and No. $8\frac{1}{2}$ to the high heat gutta-percha. According to Kirk the low heat gutta-percha contains about 1 part by weight of gutta-percha to 4 of zinc oxid; in medium heat the ratio is 1 to 6 or 7; and in the high heat specimens the gutta-percha is almost saturated with zinc oxid.

In some of the products materials other than zinc oxid are used to mix with the gutta-percha. The proportions, however, remain about the same. Calcium carbonate, some of the sulphates, silica, and other oxids are among the substances claimed to be substituted for the zinc oxid.

Physical Properties.—Gutta-percha in the pure state is almost colorless, the small amount of coloration varying from rose to grayish white. It is inodorous and insipid. It is naturally cellular in structure, but if drawn out its texture becomes fibrous and more resistant lengthwise and less transversely. It will not break until a load of about 25 kilograms per square millimeter has been applied to it. It is but slightly elastic. It is a very good non-conductor of both heat and electricity. It contracts in hardening, *i. e.*, cooling. Its density varies from slightly under that of water to slightly over it, depending upon the compression given to it in forming it into sheets. To the vital tissues it is very bland. Gutta-percha which has been in the mouth for some time often becomes harder, and

[1] Dental Formulary, p. 21.

its surface porosity is increased. Kirk states in regard to these changes: "The increased hardness is observed in such situations as those in which putrefactive decomposition occurs; that is, in places where there is an evolution of hydrogen sulphid; the gutta-percha apparently undergoes a species of vulcanization. It becomes somewhat porous in those situations where the formation of a solvent is active (lactic acid), which abstracts the soluble zinc oxid from the mass. The pink variety containing the insoluble mercury sulphid does not become porous, but wears with a comparatively smooth surface when subjected to attrition." This would seem to explain some of the changes very satisfactorily, but there are some where other explanations would seem to apply. For example, gutta-percha which has been exposed to air and light becomes friable like rosin, and its solubility in certain reagents is increased. If, however, the gutta-percha be submerged in water no perceptible change is produced. Oxygen aided by light is supposed to be the factor of prime importance in this change and as a result the process is generally spoken of as oxidation, although some refer to it as resinification, since the extent of the change depends largely upon the resin present in the gutta-percha. Thus, it would seem that oxygen produces a condition in gutta-percha quite analogous to the one observed by Kirk which he has attributed to the action of sulphids. In both cases, however, whether the gutta-percha be in the mouth or out of it, the change is apparently what he has called "a species of vulcanization." What Kirk states regarding the porosity of the surface is probably true. It would seem, however, since the solubility of gutta-percha in alkalies increases with oxidation, that there was a chance for the surface to become porous in the absence of lactic acid. Gutta-percha in the normal condition is insoluble in dilute acids and concentrated alkaline solutions. It is soluble in carbon bisulphid, chloroform, coal-tar oils, benzol, boiling ether, and oil of turpentine.

Indications for Employment.—Gutta-percha in its white and pink forms, and in the three classes, low, medium, and high heat, is used as a temporary filling material for both the temporary and permanent teeth. Its non-conductivity makes it a good material to place near the pulp. Conditions are met in which the use of gold, amalgam, basic zinc phosphates, and silicate cements alone is contraindicated because of the close proximity to the pulp. In such cases a thin layer of gutta-percha may be placed over the pulp, after which the permanent filling materials may be inserted without serious injury to the pulp from thermal changes. It has been quite a common practice to fill deep undercuts with gutta-percha and cover it with amalgam or cement, or cement and gold, but recent requirements for better cavity formation seem to have created a demand for a harder material, and as a result the basic zinc phosphates have been more widely used.

Gutta-percha is generally used to fill the pulp chambers of devitalized teeth, but even here it is, as a rule, conceded better practice to confine it to the root portion of the pulp cavity, and to fill any remaining portions which require a similar plastic material with one of the best basic zinc phosphates. It has been used extensively for cervical cavities in molars and bicuspids which do not extend to the masticating surfaces, but the demand for better oral hygiene is such that this practice has become less common except for relatively temporary operations. It has been used for all classes of cavities in the temporary teeth, and seems often to be practically the only available material which will meet the requirements of these cases. There is a tendency, however, to use less gutta-percha in the temporary teeth because of the demands of orthodontists for the retention of normal contact when restoring proximate portions of these teeth. There is likewise a tendency to use it less in other locations in the deciduous teeth for the reasons previously given in regard to better oral hygiene.

To the casual observer it might seem from this that there was little use to which gutta-percha might be put. Such, however, is not the case. Instead, there are a great many places where gutta-percha seems to satisfy more of the requirements than any other material. There are places, however, where its insertion represents almost anything but cleanliness. Many have a misconception regarding the impermeability of gutta-percha, and as a result are reluctant to substitute other materials when it can as well be done.

Dr. Black[1] says: "The trial that has been made of gutta-percha for the exclusion of moisture for long periods of time from ocean cables has shown its absolute impermeability." The fact that gutta-percha, used as a cover for ocean cables, is almost impervious, is true, but it is to be regretted that this statement was not qualified somewhat, because as it stands the average person would take it that gutta-percha was likewise impervious in the mouth.

Attention has already been called to the fact that gutta-percha did not combine perceptibly with the oxygen of water, but that it did with the oxygen of the air in the presence of light. Under the latter conditions gutta-percha *undergoes rapid decay*, and gives off an acrid odor. Kirk has called attention to the action of sulphids upon gutta-percha. Thus, while gutta-percha is impervious when inserted, it undergoes decay from at least two causes. Of course it will remain in the mouth for a considerable length of time before the decay becomes very perceptible, but fillings of long standing will show considerable change.

Gutta-percha is still a very useful material, but it should not be

[1] Operative Dentistry, vol. ii, p. 362.

allowed to remain exposed to the oral fluids for any great length of time. It may be used to set almost all kinds of crowns on roots which have been prepared for their reception, but should be allowed to remain for a comparatively short time only. Often an operation may be nearly complete, but the operator may wish to do something more before a crown is placed permanently. In such cases a little gutta-percha which has been made plastic by heat may serve to retain a crown.

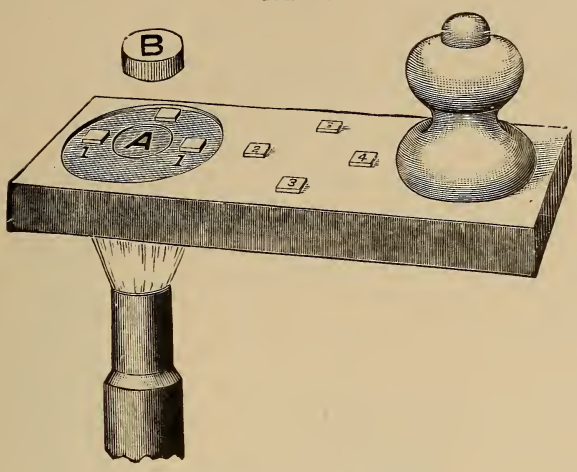
The same is true regarding its use for fillings. In an extensive inlay practice gutta-percha is almost indispensable as a temporary stopping from the time the cavity is prepared until the inlay is ready to be set. It is usually best not to allow much time to elapse between the preparation of the cavity and the setting of the inlay, but in an extensive practice occasions continually arise in which this is necessary. Gutta-percha may be used for sealing in treatments in the teeth when the cavity is sufficiently large to permit of its adaptation without compression of the pulp, or where the stress of mastication will not dislodge it. Dr. Black[1] states that "It should be the only material used for sealing in dressings and for the temporary stoppings in connection with treatments." As he says, gutta-percha is a trying material to handle until the technique of its manipulation has been mastered, but it is difficult to understand why he should declare that it is the *only* material which should be used for sealing in dressings, etc., when it is generally conceded that the basic zinc phosphates fulfil many requirements better than gutta-percha. For example, suppose an accidental exposure is made in the preparation of a cavity of a young patient where the pulp is near the surface, or suppose that the exposure has been made by caries and the pulp is in a highly inflamed condition. In either case the medicinal agent would probably be mixed with one of the nicely prepared oxids as a carrying agent and gently placed over the exposure.

As a sealing for the cavity, shallow as most are, nothing would seem to meet the requirements as well as one of the adhesive basic zinc phosphates, which could be applied without perceptible pressure. There are many cavities which present a different problem. They may be deep and easy of access. In such cases gutta-percha would be preferable to any other material.

One of the first considerations is that the surfaces to which gutta-percha is applied should be dry and free from greasy materials. This may be accomplished by the adjustment of the rubber dam or by the use of rolls and the aid of an assistant, according to the case treated. If the gutta-percha is to be inserted into a cavity the walls should be parallel or even have slight retaining points, although in most cases

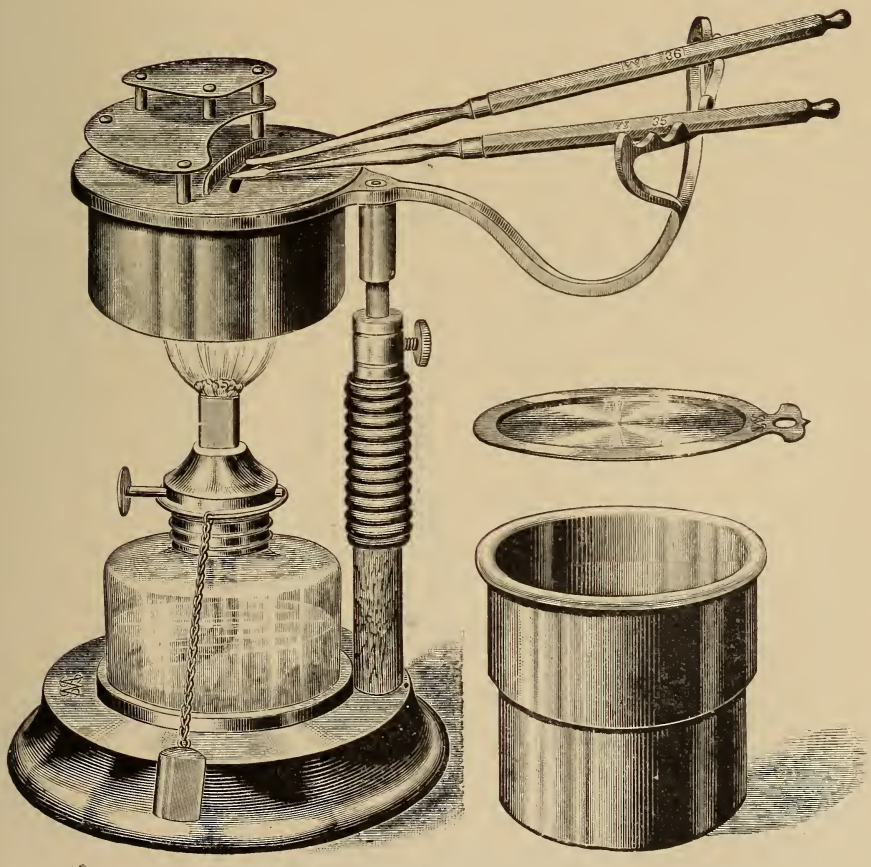
[1] Operative Dentistry, vol. ii, p. 361.

Fig. 314



Thermoscopic heater for gutta-percha.

Fig. 315

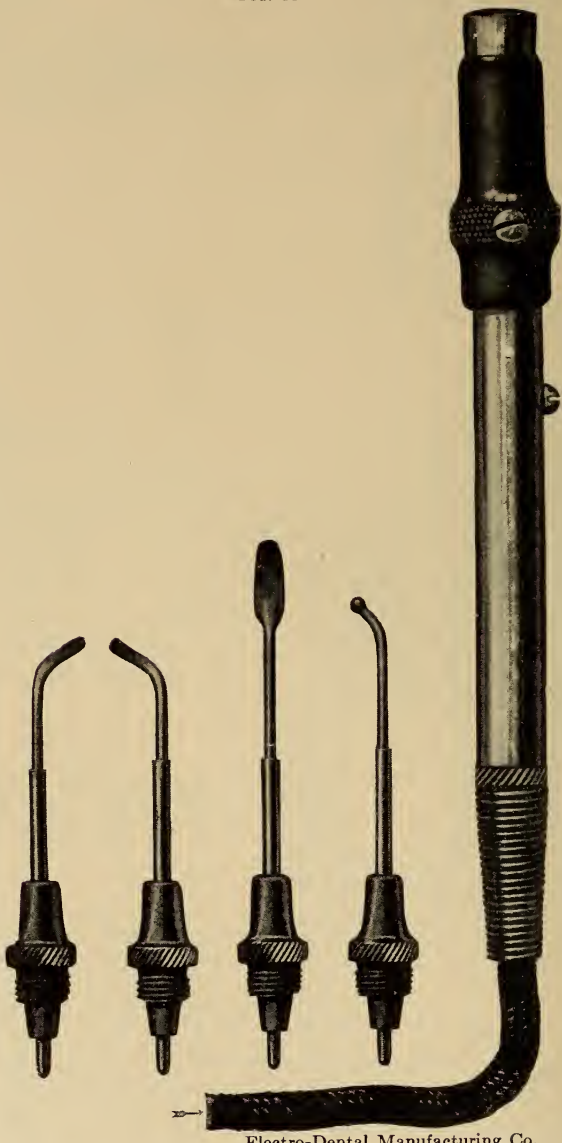


Flagg's gutta-percha softener and tool heater.

the cavity formation may be varied somewhat from that for gold or amalgam.

When the cavity has been prepared for the filling it is often found advantageous to moisten the walls with eucalyptol or cajuput oil.

Fig. 316



Electro-Dental Manufacturing Co.

Trimmer for gutta-percha heated by electricity.

This will soften the gutta-percha somewhat and add to its adhesiveness. The gutta-percha should then be made plastic by passing it

over the flame or by placing it upon one of the specially designed heaters. It is often convenient to use the different varieties of gold annealers for this purpose. The heater most commonly used is made of steatite, and is shown in Fig. 314. The heat-retaining properties of soapstone, together with its desirable surface, make it as good a heater as any yet designed. After the gutta-percha has been softened it may be rolled into a single piece of a shape convenient for insertion, and packed in place with cool instruments. It may also be inserted gradually by adding piece after piece to the walls of the cavity and the already inserted gutta-percha. This method is usually better if there is not easy access or if there is danger of compressing the pulp

Fig. 317



Hot air syringe.

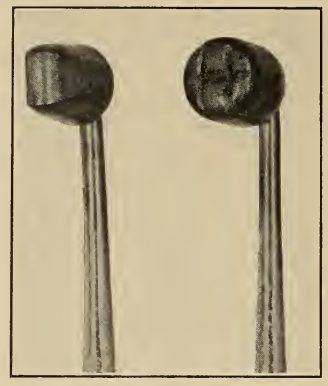
or forcing medicinal agents through the apical foramen in devitalized teeth. After the cavity is filled it should be trimmed to shape with the ordinary plastic instruments by warming them to a point where they will cut through the gutta-percha without tending to draw it from the cavity. The instruments should be heated gently in the flame or in one of the heaters, as shown in Fig. 315. Several instruments which are heated by the electric current have been designed for trimming gutta-percha (Fig. 316). They are very useful for some operations, but, as a general rule, a little more clumsy than the regular plastic instruments.

For finishing some gutta-percha fillings, where it is not necessary to

direct the blast of hot air against the soft tissues, the electric hot air syringe (Fig. 317) is very useful. It may be used in heating crowns which have been set temporarily with gutta-percha. With this instrument a blast of hot air may be directed against a porcelain crown, having a metal post, until it can be easily removed. When the hot air syringe is used to soften the gutta-percha only very sharp instruments should be used to trim off the excess, or the mass will be moved in the cavity. In general, gutta-percha should not be warmed after being inserted into the cavity, but should be chilled and trimmed with warm, sharp instruments. Gutta-percha may be trimmed into shape with the ordinary plastic instruments by warming them. It is better, however, to use more of the sharp-edged instruments, such as carvers and excavators. Heat may also be conveyed to large masses of gutta-percha, especially in removing crowns set with this material, by heating a larger burnisher and placing it upon the mass of gutta-percha. It is still better to place a good-sized piece of copper upon an instrument handle (Fig. 318).

For the use of gutta-percha as a root canal filling see Chapter XIV.

Fig. 318



Gutta-percha with Other Materials. — Temporary Stopping. — This material differs from ordinary gutta-percha chiefly in its working qualities. It is prepared from both white and pink gutta-percha by the addition of some of the gums or waxes, together with other materials, such as certain sulphates, carbonates, or oxids.

It is also made without the gums or waxes. It may be prepared so that it exhibits considerable adhesiveness by the addition of Burgundy pitch. These preparations are designed for a variety of purposes; their principal use is the stopping of excavated cavities for a short time.

As the name implies, they are intended for work more temporary in nature than that which would require gutta-percha. As a result

of their use for the most temporary operations, many of the qualities of other plastics have been given to this material by the addition of some of the above-named materials. Many of these preparations remain quite hard in the mouth, although some are less resistant than gutta-percha, and more plastic in every way. The most conspicuous differences between them and gutta-percha is that they are generally softened with lower heat and have little or none of the toughness and stringiness so prominent in gutta-percha. Their manipulation is similar to that of gutta-percha.

Gutta-percha and Gum Shellac.—Gutta-percha may be mixed with gum shellac to make a stiff and yet tough material, for use largely as a base-plate. It may be used, however, for a variety of purposes where other forms of gutta-percha would scarcely be rigid enough.

Gutta-percha with Medicinal Agents.—Such substances as oxid of copper, finely divided tin, silver nitrate, eucalyptol, creosote, etc., are often incorporated with gutta-percha. It is claimed by the makers of some of the gutta points supplied for filling root canals that the process of refining the crude gutta-percha removes a natural oil which should be supplied before the points are suitable for use. The addition of some of the oils in such cases not only supplies what it is asserted to have been removed, but for a time makes the points more or less antiseptic.

The other substances mentioned are less frequently added to gutta-percha. The salts of copper and finely divided tin can be advantageously incorporated when it seems imperative to leave gutta-percha in the mouth exposed to the saliva for some time. The use of gutta-percha with either of these materials is limited to remote parts of the mouth on account of their color. The manipulations of these mixtures is similar to that of gutta-percha alone. When these two materials, or other similar substances, are combined with gutta-percha, the resulting product is not unlike it, but some of the properties of the combined substance are added.

TIN AND ITS COMBINATIONS

Another material which hardly belongs under the head of plastics is tin. It possesses some plastic properties, however, which make its brief consideration in this chapter admissible. Tin as used by dentists is a white metal with a brilliant luster. It is quite malleable, although less so than gold. It is not very tenacious, comparing with gold in the ratio of two to seven. Its melting point is very low, and its annealing point likewise low, annealing usually being accomplished by keeping the tin under boiling water for five or ten minutes, and allowing it to cool there. Like gold, it is free from change in volume due to chemical change, its only change in volume appearing with thermal variations.

It is an inferior conductor of heat and electricity. In an alloyed or finely divided state it tarnishes readily, although when used as a coating for articles made of iron, etc., or in ingot form, it remains of a comparatively bright color.

Like gold, it can be welded in the cold state. This latter property is still questioned by many who hold that its use in dentistry as a filling material is made possible through a mechanical entanglement of the pieces of tin used. This supposition, however, seems to be based upon observations made on tin in the form of foil. If the more recently introduced tin shavings are used, while freshly cut, the cohesive property appears in an unmistakable manner. This cohesive property seems to be lost somewhat with the rolling and beating necessary to produce the tin in sheet form. Like gold foil, its cohesiveness is lost, either by a union with or a condensation upon its surface of substances often present in the atmosphere, and this cohesiveness cannot be restored by heating.

It may be seen that tin resembles gold more closely in many of its properties than it does the other filling materials. Probably those who have been most successful with it have treated it in much the same manner as non-cohesive gold. Its use alone or in combination with gold foil seems to be indicated in places where a permanent operation is desired, but which cannot be well done with gold foil because of lack of access. In very inaccessible places the plastic nature of tin usually permits of a much better adaptation to the margins and walls of the tooth than gold foil. Tin is generally selected for cases in which gold foil could be employed were it not for the difficulty of access and the fact that better results are obtained when some tin is used in connection with the gold. Some, however, use it in cavities of easy access because they believe it has great preservative qualities. Those who believe most strongly in its preservative qualities often practise little or no extension to areas of relative immunity, and yet their success with tin is as great as that of those who do. Such successes may be attributed partly to the plastic nature of tin and its consequent ready adaptation, but the consensus of opinion would probably favor the theory that the tin possesses some inherent preservative qualities.

There are few who do not feel that tin has some property, peculiar to itself, of inhibiting caries, and yet there seems to be no definite understanding of the process.

Dr. W. T. Miller[1] has stated that tin is neither antiseptic nor therapeutic in action; Marshall,[2] that it is decidedly antiseptic when oxidized; and Ambler,[3] that "the filling itself will prevent caries, but the oxid of tin formed in the mouth affords an additional barrier." Thus, it may be seen that there are a variety of views as to how tin saves teeth.

[1] Dental Cosmos, vol. xxxii, p. 714.
[2] Operative Dentistry, p. 286.
[3] Tin Foil and its Combinations, p. 42.

Many have observed that not all tin fillings were oxidized. Neither had any other salt formed to any appreciable extent, and yet the tooth tissue was protected equally well. Probably most tin fillings which have not turned black after some time in the mouth have been located where there was abrasion of its surface, although there seems to be some difference in the action of the oral fluids upon this material.

The preservative qualities of tin claimed by so many seem not entirely dependent upon either the antiseptic action of tin or its salts, but also upon a change produced in the tooth tissue which is decidedly antagonistic to the progress of caries. Those who have examined cavities which have had tin fillings for some time almost invariably observed a tissue change which in the case of other filling materials occurred only when alloys containing large percentages of copper were used.

Tin may be used either alone or with gold. Many operators employ it in the form of foil or shavings to fill the cervical portion of proximate cavities in remote parts of the mouth or at least obscured from view. In such cases it is usually manipulated like non-cohesive gold, and is used as a base for the remainder of the filling, which may be either non-cohesive or cohesive gold. It possesses too much flow for a successful base for gold fillings when much force is to be applied to the filling, and should be used in this manner only when the force of occlusion is distributed over nearly all the teeth.

Tin foil may be used with gold in the form of a "tin-gold," a sheet of tin and a sheet of gold being rolled together. This combination may vary, some operators preferring slightly more of one metal than the other. It may be folded or crimped to make a material which works in slightly different fashion, but in either case the tin and gold are inserted together.

"Tin-gold" is usually made from the thinner tin foils and non-cohesive gold foil, No. 4 being very good for both. It is inserted in the same manner as non-cohesive gold, and when finished possesses many of the properties of that material, but is more plastic, a poorer conductor, different in color, and somewhat weaker at the time of insertion. Many have observed that "tin-gold" fillings after some time have changed in character. Instead of being relatively malleable as when inserted, the mass seems to form a typical gold-tin alloy by becoming harder and more brittle. There is good reason to believe that this is what has taken place.

Recent investigations tend to show that many metals will alloy with other metals, if they are pure, when brought into intimate contact in the absence of heat. As long ago as 1878, Professor Spring, of Liège, made studies of the different methods of producing alloys by compressing the constituent metals, and was able to produce certain alloys in the absence of heat that possessed physical properties quite

analogous to those produced by heat. Spring's studies have since been extended and his observations have been confirmed by others until these phenomena are looked upon as comparatively ordinary occurrences.

Tin-gold may be used in places where either tin or non-cohesive gold are used. The insertion and finishing of the filling are accomplished in the same manner as non-cohesive gold or tin.

Some operators have used tin foil in combination with amalgam with a degree of success, but it has disadvantages when used in this manner that do not occur when it is employed with other materials. It will be recalled that change of volume in filling materials is either physical, due to thermal variations, or chemical, due to the union of two or more substances. Tin alone is subject to physical change in volume only, and this is probably also largely true when it is used as the base of a gold filling. Likewise probably little chemical change in volume occurs during the early stages of a tin-gold filling, although it may be considerable during the later stages.

When amalgam is used as a covering for tin fillings, as is done by some operators, a contraction of the whole mass is likely to result if the amalgam has been made from a low percentage silver alloy, but not so much so if a rapid setting alloy has been used. It would seem that there is little or no occasion for the use of amalgam with tin, although some regard it a useful combination. When amalgam is used with tin it is inserted as a covering for it so that the surface of the filling will be harder than it would be if made entirely of tin. Such operations, however, are confined to remote parts of the mouth.

LININGS FOR CAVITIES.

In the practice of dentistry it often becomes necessary to line the walls of a cavity or to coat the surface of teeth with substances which are poor conductors or will prevent the irritant action of certain filling materials, such as some of the cements. Of the materials available for this purpose the various varnishes are most used. They are solutions of gums and resins in alcohol, chloroform, and ether, which can be applied in a film as a protective to the walls of cavities or surfaces of teeth.

Sandarac in alcohol, and hard Canada balsam, copal, or damar in ether are among the more common of these materials.[1] The preparation known as Kristaline, a solution of trinitrocellulose in anhydrous amyl acetate (Kirk), is also used. Virgin rubber or gutta-percha dissolved in chloroform may be used in the same manner; in most cases

[1] For some formulæ of these varnishes the reader is referred to Dr. Prinz's Dental Formulary.

the latter two are less desirable, as they are less adhesive. Silver nitrate has been extensively used as a lining for cavities, especially in cases of carious tissue whose removal was impractical. It must not be regarded as a non-conductor in the sense that the varnishes are, however, because it is reduced to metallic silver when brought in contact with organic substances, hence the dark color. These different linings, especially the gums and resins, are of great value in preventing galvanic disturbances and rapid conductivity of thermal impression produced by amalgam. They are also useful under gold fillings and the full and partial caps often placed upon teeth. They are also useful in preventing the irritant action of both the basic zinc phosphates and the silicate cements. In the earlier stages of the setting of either class free acid is likely to form, while during the stages of disintegration acid salts are apt to occur in contact with the dentinal walls if a lining has not been used.

Formerly some of these linings were used to prevent the discoloration of tooth tissue by amalgam, but this is not necessary with the more recent ones. It is, however, a good precaution to take if copper amalgam is used. These linings may be applied to the walls of the cavity or surfaces of a tooth with the ordinary pliers and a bit of cotton, or directly with any small instrument. Before their application, the surface should have had the regular treatment given to cavities preparatory to filling and should have been wiped with a solution of sodium carbonate to remove traces of greasy substances. After the lining has been applied it should be allowed to stand until the greater part of the volatile portion has disappeared and the lining is quite hard.

CHAPTER XII

COMBINATION FILLINGS

By MARCUS L. WARD, D.D.Sc.

A careful study of the materials available for use in filling teeth shows that no one of them quite meets all the demands of modern dentistry. Some possess artistic qualities but lack strength. Others that possess the best strength are the farthest from nature in color. This is also true in regard to their destructibility in the oral media. Some are wholly insoluble, while others are quite soluble in saliva, products of fermentation and certain food substances. Some materials are excellent conductors, while others are very poor ones. One or two are liable to considerable alteration in volume due to chemical change, while others are only subject to change in volume due to thermal changes, one or two possessing a very small co-efficient of contraction and expansion.

The alloys and cements now in use represent attempts to combine the desirable qualities of several materials in one product. These products often show that a material with only one desirable quality and several undesirable qualities may be introduced as a filling provided the former is pronounced. Even the most skilful makers have not yet succeeded in producing a material even approximately suitable for use alone in all cases.

A filling material should be indestructible in the oral media, should approximate the color of the teeth, be free from contraction and expansion after being made into fillings, should resist attrition and the force of mastication, be a poor conductor, easily manipulated, and quite adaptable to the walls of a cavity. Thus the requirements for a dental filling material are enormous and out of proportion to the demands made upon most materials in use in allied sciences.

There is a constant desire that a filling material should possess one or more additional qualities and an increasing tendency to combine two or more materials to obtain the quality sought. The zinc phosphate cements have many excellent qualities and are almost invaluable. Their one good quality above all others is the property of adhesiveness, a quality sought but practically absent in all other filling materials. They are generally manipulated with ease, their color is good, and under proper handling they are relatively free from contraction and expansion, but they are not indestructible in the mouth. Gold has many excellent qualities, being strong, wholly indestructible in the mouth, and free from contraction or expansion caused by chemical changes. It is adapt-

able to many cases, but its color is poor, its insertion is tedious to both operator and patient, and it is an excellent conductor. Amalgam may be similarly criticised. While it may be inserted in places inaccessible to gold and last longer than most cement fillings, as a whole its qualities are poor when compared with the ideal standard for filling materials. It is almost but not entirely indestructible in the mouth. Its strength is indefinite. It is subject to chemical change in volume after insertion. Its color is poor and it is a good conductor. Certain of these objectionable qualities are very conspicuous when these fillings are used alone or in places where another filling material is indicated. For example, the examination of a large number of amalgam fillings in occlusal cavities will show more imperfect edges than in the case of fillings of a similar shape located on the buccal or proximal surface. The difference between these classes of fillings is due to the fact that one class is subjected to stress and the other is not.

Even when strongest, amalgam is relatively brittle and the change in volume is usually sufficient to cause fracture of the amalgam when in the course of time it is no longer supported by the cavity margins and stress is applied. Similarly located gold fillings do not show the differences noted with amalgam, as gold is not brittle, and also remains more constant in volume. When placed against a margin it does not rise up above it nor shrink below it, as do most amalgam fillings. The deduction seems to be that of the two materials, gold is much better for locations where stress is applied.

If a number of proximal gold or amalgam fillings be examined, the metal is usually found to show through the enamel, oftentimes conspicuously, on the buccal or labial side. This is particularly true when the cavities are quite deep. In such an examination, however, a few fillings are usually found near the surface which do not appear as dark as some others. Closer examination shows that some of the light-colored cements have been placed between the filling and the wall of the cavity. There can be little doubt but that the combination of the two filling materials has brought about a better result than one material could do. Thus, the adhesive quality of the cement may be utilized to make metal fillings more sightly as well as to strengthen the frail walls of such cavities. For this reason it is often desirable to combine in one filling two or more materials. It is the careful selection of filling materials and the ingenuity in combining them that saves the most teeth.

Some seem to adhere to the idea that a material adapted for one place is equally adapted for others, and that combination fillings are resorted to because they are easier made than fillings of one material. Such is not true. If an operator gives his patients his best services he will make the same effort to combine the qualities of different filling materials that the makers of these products make in combining the qualities of different substances for a single filling material.

It may be said truthfully that an operator's services may be measured only by his ingenuity in carrying to completion the plan adopted by the makers of filling materials. In this chapter only the mechanical operation of inserting the filling will be considered. All operations upon the pulp and root canals will be eliminated and the teeth will be considered ready to receive fillings. Not all combination fillings will be described. Only those most important will be considered, leaving those of lesser importance to the ingenuity of the operator.

CEMENT (ZINC PHOSPHATE) AND AMALGAM

This combination is one of the oldest and has been most serviceable in saving teeth that would otherwise have been crowned or lost. Originally the combination was employed in cavities where the interior of the cavity was much larger than the orifice. Such cavities are most frequent on the occlusal and proximal surfaces of the teeth. Many cases are seen where little but the enamel is left, which, when supported by an adhesive material, will withstand the ordinary stress of mastication.

Fig. 321 shows an occlusal cavity of this kind, which consists principally of a shell of enamel. To open such a cavity until there were no undercuts would obliterate the occlusal surface, while to fill it with a non-adhesive material would result in the breaking down of the overhanging ledges of enamel under the ordinary stress of mastication. It may be recalled in this connection that enamel is much weaker than dentin, that it requires a piece of dentin approximately $\frac{1}{10}$ inch thick to sustain the force of mastication in the molar region, and that no strength is added to the tooth by metallic fillings, the inlays excepted. Hence, filling such cavities with amalgam or gold alone is folly.

The combination of an adhesive material with a metal, however, gives an operation which often withstands the work of mastication for years. There are two methods for combining cement and amalgam. The first consists, in occlusal cavities, of filling the entire cavity with cement mixed to a putty-like consistency and allowing it to harden so that it may be cut with sharp instruments without moving its body and then cutting into it, a cavity with parallel walls of the size of the orifice of the cavity. Such a filling has the appearance of an amalgam filling, but it is in reality a cement filling with a veneer of amalgam, which protects the cement from the solvent action of the saliva and from becoming abraded by attrition. In large proximal cavities especially, where the pulp has been removed, a similar procedure may be pursued to advantage. A cavity such as shown in Fig. 319 may be filled with cement and made to appear as Fig. 320.

As may be seen, the part of the cavity left to be filled with amalgam is really a veneer covering the proximal and occlusal portion of the

cavity. In these cases the cement forms a support for the frail walls which a metallic filling could not supply. Cement must not be used in too great quantities if the best results are to be obtained.

Amalgam in thin layers will not withstand the force of mastication unless it has been packed into the cement while soft, thus uniting the amalgam to the cement. This constitutes another method of combining amalgam and cement in the form of an inlay, and is known as an amalgam inlay. The popularity of the inlay method of filling teeth seems responsible for the wide use of this combination.

In large occlusal cavities such as shown in Fig. 321, the cement should be mixed to a consistency suitable for setting inlays and carried to the cavity with a Spalding loop (Fig. 322) or other suitable instrument and teased over the entire surface of the cavity.

Fig. 319



Devitalized molar tooth with cavity outlined.

Fig. 320



Molar tooth devitalized with cavity outlined and cement in place to be covered with amalgam or gold.

Fig. 321



Large occlusal cavity partially filled with amalgam and soft cement showing soft cement oozing out of cavity at margins.

Amalgam which has been previously mixed and kept moving by the assistant so that it will not become too stiff is now packed in large pieces in the bottom of the cavity from the centre to the sides, allowing the excess cement to flow out of the cavity (Fig. 321). Care must be exercised not to leave a visible layer of cement between the amalgam and cavity margin, or the cement will dissolve out. The amalgam should be carefully finished to the edges of the cavity, so as to cover the cement as nearly as possible. The cement is usually reduced to a very thin layer by this method of insertion, although a sufficient amount remains to unite the cavity wall to the amalgam, thus supporting the frail walls in a manner impossible with amalgam alone.

In filling proximo-occlusal cavities which have frail walls the same technique may be pursued, except that the thin cement should not be

placed along the border of the cavity next to the matrix and the amalgam should be packed along this border, first causing the excess cement to flow out of the occlusal portion of the cavity. The amalgam and cement method has been used with advantage in highly sensitive cavities where a proper retaining form could not be obtained. Fig. 320 shows an approximal cavity which might be filled with amalgam and soft cement, often giving good results. Such operations, however, are not always the best possible, but perhaps the best under the circumstances. The so-called

FIG. 322



Spalding loop for carrying cement.

amalgam inlay has also been used successfully in building up broken-down molars and bicuspids. There is a tendency to use soft cement under all large amalgam fillings, regardless of the necessity for an adhesive material to strengthen the tooth or to retain the filling. The lessened conductivity of the combined cement and amalgam seems in many cases to warrant the use of the two in preference to amalgam alone, while in other cases the improvement in the color of the tooth is quite marked.

CEMENT AND GOLD

Cement and gold may be used in posterior cavities in much the same manner as has been described for amalgam. Gold, however, cannot be packed into soft cement in the same manner as amalgam. The class of cavities selected in the posterior part of the mouth to be filled with gold, as a rule, do not require the adhesive material, and besides it is almost impossible to pack gold into soft cement anywhere except on the floor of the cavity. Filling occlusal and proximo-occlusal cavities partially full of cement (Fig. 320) and allowing it to harden is commonly practised, since it is comparatively easily done and the filling so inserted has the same advantages with gold as it has with amalgam. Cement inserted in this manner must be allowed to harden sufficiently to resist the impact of the mallet in condensing the gold without being disturbed, otherwise the gold will often become loose after the operation is partially completed. Some operators use a small amount of rapid-setting soft cement in the base of all cavities to be filled with gold. In such cases some of the so-called "sponge" golds are usually employed to pack a quantity into the soft cement, after which, allowing the cement to harden somewhat, more of the "sponge" gold or some of the foil golds may be built upon the gold which has been packed into the cement.

Care must be exercised to use sufficient gold so that the soft cement will not ooze through the gold, thus destroying the cohesiveness of its

surface. The same care should be exercised not to use too much cement, but only enough to fasten the gold to the surface of the cavity. This method of combining gold with cement will be found useful in the anterior teeth and the bicuspids where a dark area is likely to be produced by the metal underneath thin layers of the tooth structure. If a light-colored cement is used, the effect is often much better than it otherwise would be. Cases of hypersensitive dentin often present complications which make it necessary to resort to cement for anchorage. It may not be necessary for appearance, nor always necessary to gain strength, but it may be the only means of securing anchorage. This is oftentimes true in the teeth of young patients.

Teeth that have been somewhat discolored may often be made much lighter by lining the cavity with a light-colored cement before inserting gold. Cavities in central incisors, having frail enamel walls that were in the past frequently filled with cement and gold, and would still be filled to advantage that way if gold were to be used, would at the present time preferably be restored by most operators by the porcelain inlay. In fact, the whole field of operative dentistry has been so changed by the introduction of porcelain and gold inlays and silicate cements that the practice of filling such cavities with cement and gold, amalgam and gold, or cement, amalgam, and gold, has become almost obsolete.

AMALGAM AND GOLD

Amalgam and gold have been used to advantage in many places, principally, however, in proximal cavities in bicuspids and molars which involve more or less of the occlusal surface. Before the advent of gold and porcelain inlays and silicate cements, gold was used to cover amalgam on the buccal surfaces of the bicuspids and molars much more than now, although some operators still adhere to this method in preference to the more recent ones. The filling of mesio-approximal cavities in upper bicuspids and molars which involve considerable of the buccal surface, even with the lighter-colored amalgams, is regarded as especially poor practice by most operators, since there are a variety of combinations which may be used to prevent the exposure to view of the unsightly amalgam. Many enthusiasts hold that such cavities can be filled with the silicate cements, while the more conservative claim that they can better be filled with amalgam and gold.

Fig. 321 shows a cavity which in most cases is extremely difficult to fill with gold foil because it is so wide at the cervical portion and extends some distance below the gum line. It is equally difficult to keep such a cavity perfectly dry during the insertion and finishing of a silicate cement and these fillings are of little value unless they are kept free from moisture during the first few hours of setting. If such cavities

do not extend too far laterally it is often better to cut them open to receive either a gold or porcelain inlay, but in many of them caries has proceeded too far to admit of either. Such cavities can be filled with amalgam and the amalgam allowed to harden, after which the portion exposed to view may be cut away and filled with gold.

When gold and amalgam are used in combination it often becomes necessary to make a retaining form in the amalgam for anchoring the gold. There is no union between the two after the amalgam has hardened, and often such cavities can be filled only by gaining a retention somewhat remote from the place where gold is to be placed, thus requiring the retention for the gold to be placed in the amalgam. Some operators use amalgam and gold to fill occlusal cavities similar to the one shown in Fig. 321. The advantages of this combination, however, over that of cement and gold in such places are not very apparent. Many in the past have considered it necessary to place cement under all amalgam fillings which were to have gold in combination, in order to increase the strength and to diminish the amount of discolored tooth tissue from the amalgam.

The tendency seems to be to use cement under all large amalgam fillings whether gold is used or not, that there shall be increased strength; but there seems little or no thought of preventing discoloration of tooth tissue, as with proper use of modern alloys this is extremely rare. Gold has been used with amalgam by packing the gold into the amalgam while soft, but the operation seems to be about obsolete. Recent studies of amalgams seem to make it clear that like other crystallizing bodies they should not be disturbed during the setting process, more than is necessary when placing gold over soft amalgam. Special emphasis has been placed upon using steady but firm pressure in packing amalgam and allowing it to lie still until hardened.

GUTTA-PERCHA AND CEMENT

Gutta-percha has unquestionably had its field of usefulness lessened materially within the last few years. It has been used in combination with cement, gold, and amalgam, and served a very useful purpose. The demands of the profession, however, for better hygienic conditions in the mouth has practically eliminated it except for the most temporary operations. Gutta-percha fillings which are expected to remain for months are fast being regarded as bad practice, regardless of whether the gutta-percha is in combination with other materials or not. The recent demands of orthodontists for a harder material with a well-restored contour for proximal cavities has also served to lessen the amount of gutta-percha used.

Gutta-percha may be used in combination with cement by placing

it at the cervical third of proximal cavities where cement is often dissolved out first, but the tendency is to refrain from inserting gutta-percha where it is exposed to the oral fluids. This has been one of the methods employed to meet the requirements of some of the perplexing operations on the deciduous teeth. Many operators adhere to the use of oxyphosphates of copper for all operations on the deciduous teeth. Others follow the advice of many orthodontists by caring for the deciduous teeth with amalgam alone or in the form of an inlay with oxyphosphate of copper for the cementing medium. A few use inlays in the deciduous teeth, but those who use gutta percha appear for the greater part to be doing so with an apology.

CEMENT AND ALLOY

A mixture of thin cement and alloy fillings has been recommended by some for operations in remote parts of the mouth where it is desired to prolong the durability of a cement filling. The main object of the alloy is to protect the cement somewhat from the fluids of the mouth.

With the development of the inlay method a tendency has developed to use cement and alloy in the form of an amalgam inlay (Fig. 321), instead of in this combination. If cement and alloy are to be used the cement should be slow setting. A comparatively slow setting cement is mixed to a creamy consistence and the alloy then worked into it to the desired consistence.

The advantages of cement and alloy over amalgam are adhesiveness and non-conductivity. Its advantages over cement are durability and hardness. This combination has been of service in restoring badly decayed teeth and in some sections still seems to be in favor, but, like gutta-percha, it is being eliminated by the recent demands for better oral hygienic conditions.

BASIC ZINC PHOSPHATES AND SILICATE CEMENTS

This combination is of comparatively recent origin and has been found necessary to carry out the insertion of the silicate cements. One of the first observations in the use of the silicate cements was that they were irritant to the pulps of the teeth. This is also true of the basic zinc phosphates, especially when the acid is present in comparatively large quantities, as when the cement is mixed to a creamy consistence for retaining inlays, bands, crowns, etc. There is, however, more irritation from the silicate cements as at present introduced than there is with the basic zinc phosphates. To correct this to some extent, many have advocated placing a layer of basic zinc phosphate which had been mixed rather stiff along the pulpal wall of the cavity.

As a rule, cavities requiring a lining material have only a thin lamina of dentin over the pulp, and care must be exercised not to use the basic zinc phosphate so stiff that much pressure is required to place it. It is better, however, to have the cement as basic as possible, and get the minimum of pressure in placing and the required adhesion. It is often best to precede the insertion of the basic zinc phosphate with a layer of one of the lining varnishes, while at other times the lining varnish may be used and the basic zinc phosphate dispensed with. The greater adhesion of the basic zinc phosphates over the silicate cements is keeping them in favor for filling undercuts and the deeper portions of all cavities regardless of whether it is actually necessary or not.

The basic zinc phosphates will unquestionably add more to the strength of teeth with frail walls than the silicate cements now in use, although the latter are not entirely devoid of adhesion. Owing to the uncertainty of the solubility of the silicate cements, the tendency is to leave more unsupported enamel when using it than when using other materials except the basic zinc phosphates.

Cavities that have ordinarily been extended to areas of relative immunity for the reception of other materials are being filled with basic zinc phosphate and silicate cements without such extension. Just what the judgment of the profession will be regarding this practice cannot be stated, but it is probable that more failures will attend the use of the silicate without extension than would occur from a dissolving of them and the result will be more extension of the cavities.

CHAPTER XIII

RESTORATION OF TEETH BY CEMENTED INLAYS

By W. A. CAPON, D.D.Sc.

This branch of operative dentistry has for many years been an important factor in the preservation of teeth, particularly those of poor structure precluding the use of ordinary means of restoration through the use of mallet or hand pressure gold fillings. The term inlay, accurately speaking, may be applied to any substance placed in the cavity as in one piece and held in position by an adhesive cement, but porcelain and gold are the generally accepted materials when "making an inlay" is spoken of.

The process of making a porcelain inlay is practically the same at present as when first introduced some twenty years ago, but the advent of the casting machine for gold has revolutionized that work and made it possible for every dentist to make inlays in a scientific and practical manner and enlarge his usefulness as an operator to the advantage of all concerned.

The desire for a more natural appearing material for tooth restoration existed many years before practical means were discovered, and much energy was expended toward making porcelain in some form fulfil that requirement. Pieces of porcelain matching the natural tooth have in times past been ground to fit the cavities and then cemented to place, but this class of work is hardly feasible except in labial cavities or some regular surface of the front teeth. Ready-made porcelain inlays have been kept in stock for years at the dental depots. They are in the form of rods in various shades and diameters, while others of different shapes and sizes are ground to fit the cavities and finally cemented in place, after which they are polished.

Some, however, instead of being ground to fit the cavity, require the cavity to be ground to fit them (Fig. 323).

Dr. Geo. H. Weagant, devised a set of instruments (Fig. 324) suitable for this process, consisting of five trephines of consecutive sizes, made of copper charged with diamond dust. These instruments are intended to cut pieces of porcelain out of an artificial tooth that matches the color of the natural tooth, and the cavity in the natural tooth is prepared with one of Dr. How's inlay burs (Fig. 325) corresponding in size to the trephine. This method has several serious objections, one of the principal being that, in order to give the cavity a circular shape, much tooth structure is

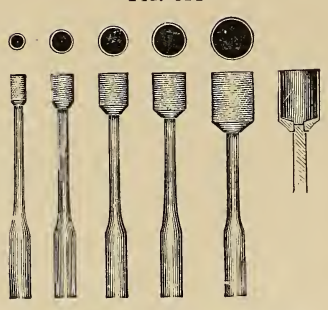
usually sacrificed. Take for example the decayed spot shown in Fig. 326. This would have to be enlarged as in Fig. 326 *b*—which is a serious objection.

Fig. 323



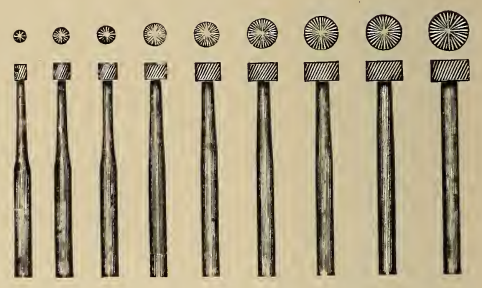
Porcelain cavity stoppers.

Fig. 324



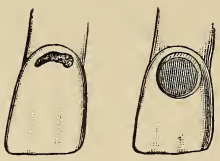
Dr. Weagant's diamond trephines.

Fig. 325



Dr. How's inlay burs.

Fig. 326



a *b*

As early as 1882 Dr. Herbert advocated glass fillings. These were made by taking impressions of the cavity in wax and making two moulds in some such material as plaster or asbestos. The ground glass was then flowed into the first mould, in which most of the shrinkage occurred. The partly formed filling was then removed and placed in the second mould, when more glass was added until the filling was complete. Even with this crude method the results were fairly satisfactory, although the margins were far from perfect and the glass was permeable to such an extent as to blacken; nevertheless, fillings were made that preserved the teeth for years.

In 1887 Dr. C. H. Land made mechanically perfect edges possible by devising the metal matrix. Dr. Land used both gold and platinum, but found the latter preferable, as platinum could be adapted with a facility equal to gold, and allowed the use of high fusing tooth body much stronger and less likely to deteriorate than bodies capable of being fused

on gold, which of necessity requires so large a percentage of glass that they, like the fillings of Herbst, lacked permanence of gloss and color.

From Land's discovery dates all effective porcelain fillings. Before this, pieces of porcelain had been ground to fit labial cavities with fair results, but the accurate adaptation of porcelain to proximal cavities was impossible until the metal matrix was evolved.

It is claimed that inlays are idealistic in their results, and this is undoubtedly true, providing certain considerations are adhered to. But it being impossible to make one material perfect under all circumstances, it is then necessary to resort to a combination that will lead to the best results. Porcelain inlays are ideal because when properly made they restore the tooth more closely to its original and natural appearance than gold or any other material. Its resisting qualities are much inferior to gold, therefore its value decreases if appearance and artistic quality are not first considerations. Gold in inlay form is then used, which justifies us in classifying the cemented inlay as an ideal means of restoration, unequalled and unchallenged.

In other words, the use of porcelain for anterior teeth and gold for the wear and tear of posterior teeth have all the characteristic of ideal fillings because they exclude germs of decay and preclude from growth those that enter. An inlay is a non-conductor of heat; it adheres to cavity walls, its manipulation is easy to the patient and conservative of tooth structure. It has :

1. Resistance to wear of mastication.
2. Resistance to the action of oral fluids.
3. Harmony of color when porcelain is used.
4. Exclusion of bacteria and preclusion from growth of those that may enter the margin.
5. Non-conductivity of heat and electricity.
6. Manipulation easy to patient.
7. Manipulation easy to operator.
8. Manipulation not destructive of healthy tooth structure.
9. Re-insertion with little preparation.
10. Duplication, which means that in many (cavity preparation) instances a duplicate is made and reserved by the operator for use in case of accident to the original.

The success of an inlay will depend largely upon four points of difference between its cavity preparation and that for those of foil, gutta-percha, amalgam, or cements, viz., upright walls, square enamel edges, no undercuts, and depth. The walls being perpendicular or nearly so, allow the easy withdrawal of the metal matrix either of platinum or gold, or in the case of the impression for casting with wax or any material for the purpose of making a model. The enamel edges are made square so that the inlay will have no overhanging frail edges of porcelain.

An undercut will prevent the easy removal of the matrix frequently

distorting it, and when using wax not even the slightest undercut is permissible. In connection with porcelain, depth of cavity has much to do with retention in fact; it is more important than various keys and irregular forms advocated by many writers on this subject. Unfortunately we cannot always get sufficient depth, and, on the contrary, many cavities, when entirely cleared of decay, are too deep to obtain an unmutilated matrix particularly with platinum; however, when this condition exists it is an easy matter to reduce it by partially filling with cement or gutta-percha.

The advantages of depth are retention, strength, through quantity of material and purity of shade by having sufficient volume of porcelain which assists materially in reducing the opacity caused by the cement.

This rule pertaining to deep cavities has not the same value when applied to the cast gold inlay, and it is well to note that the same rules which apply to porcelain inlays are applicable to matrix gold inlays, excepting that point pertaining to shading, because cavities prepared for matrices have always the burnishing feature prominent, which means curves and all surfaces accessible to the burnisher.

The following representations of various cavities in natural teeth where porcelain is indicated and applicable are shown with the same cavity prepared and ready for the matrix. By this means the student will readily note what is requisite and necessary without detailed description and technical nomenclature.

FIG. 327



FIG. 328

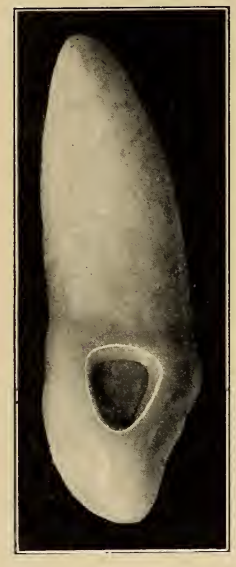
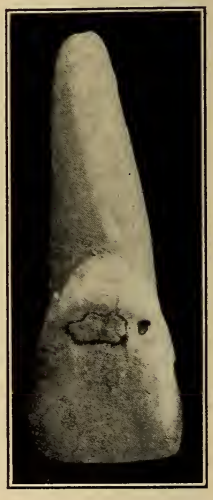


FIG. 329



Figs. 327 to 334 show simple cavities, and in each case the border has been extended beyond the outline of decay, for the same consideration

with respect to extension is applied in this class of work as if the cavity were to be filled with gold.

Fig. 330



Fig. 331



Fig. 332



Figs. 335 and 336 are in the same class but are more difficult, for they have resulted from another cause, viz., abrasion or erosion, and it is noted particularly because this condition is common, and the cavity preparation much more difficult. The depth is insufficient and the margins are

Fig. 333



Fig. 334



never defined, which necessitates extensive cutting into hard and unusually sensitive dentin, and as this kind of cavity is almost as common

in lower teeth the difficulty of preparation and general manipulation is increased. This applies to all labial cavities and is noticed more in

Fig. 335

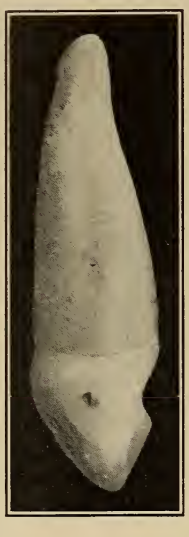


Fig. 336



porcelain operations, because when the cavity is ready the matrix must be held in position firmly, a procedure interfered with by the lower lip and the saliva. The use of rubber dam is not desirable because it reduces the working space, but it has other advantages occasionally.

Fig. 337



Fig. 338



Fig. 339



Figs. 337 to 346 show cavities presenting greater difficulties both in preparation and general manipulation. Cavities in such positions

must have plenty of space between the adjoining tooth, otherwise a matrix cannot be withdrawn or the finished filling inserted. Sometimes it is

Fig. 340



Fig. 341



impossible to get sufficient space for drawing the matrix without distortion; in such instances the cavity is prepared with this point as a first consideration. Fig. 346 shows a cavity of this kind. If there is not much

Fig. 342



Fig. 343



Fig. 344



difference in outline of the cavity labially or lingually, choose the labial side to extract the matrix; or if cutting the labial margins does not inter-

fere with the welfare of the tooth, resort to this assistance in preference to difficulties of lingual matrix extractions. In Figs. 338 and 340 the matrix under ordinary conditions will be withdrawn lingually. Figs. 339 and 341

Fig. 345



Fig. 346



show uncertain incisal edges which are reduced in Figs. 342 and 344; therefore the difficulties of drawing a matrix in this case are very much reduced, for the cavity is so large that working space is greatly extended. Large proximal cavities of Fig. 341 type, where the incisal edge is of greater strength and is retained, are very difficult and frequent. The

Fig. 347



Fig. 348



matrix formation requires skill and patience, but the reward is durability—for the inlay in this case is thoroughly protected and is rarely unseated.

Figs. 347 and 348 show a cavity on the gingival border extending under the gum margin and involving a considerable portion of the tooth mesially

Fig. 349



Fig. 350



and distally. It is a typical representation of this form of cavity and the position is one demanding a restoration with porcelain. The cavity walls are governed by its extent, for the matrix will warp if a strict rule of upright walls is carried out here. The cervical wall will not be

Fig. 351



Fig. 352



Fig. 353



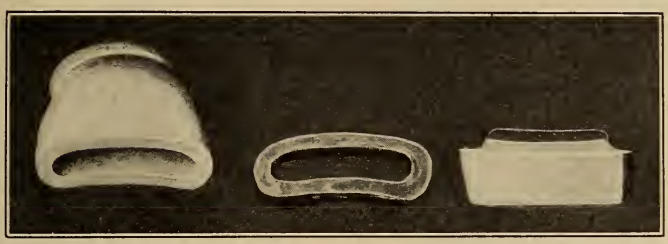
at right angles to the pulpal wall or floor, or if so made they cannot be of that form at the extreme mesial and distal border; therefore, in these

cavities strict adherence to a right angle upright wall is not possible for the best result. When the matrix is burnished it should be packed with gum camphor in preference to other materials recommended. It is not always possible to make a very extensive inlay of this kind of one piece, therefore it should be divided at the median line of tooth and two operations made.

Figs. 349 to 353 represent extensive proximal cavities or fractures extending to the incisal edge, and at a position where porcelain is of great importance. The apparent insufficient anchorage deters many operators from using porcelain, and the preparation of these cavities is the cause of more different opinions than any other. It is claimed that without a key or step on the lingual surface porcelain will not be retained by the ordinarily prepared cavity, and unnecessary cutting of good tooth structure is taught with most deplorable results—in many instances, irregularity of cavity and its borders increase the matrix-formation difficulties, therefore a simple preparation is taken advantage of. With few exceptions the cavity can be prepared similarly to Fig. 342, defining the labial and lingual walls and anchorage increased by a groove with a round bur at the gingival border resembling a deep undercut, as for a gold filling. Anchorage is also increased by grooving between the enamel plates at the incisal edge. The matrix must be burnished to these surfaces, otherwise the value of the preparation is lost. The labial outline, Fig. 352, can be varied in many ways, but angles are to be avoided whenever possible. Very often the corner is of the form of an irregular triangle tapering to a wedge point at the cutting edge. The porcelain at that point is very frail and will break, leaving an irreparable notch. To avoid this, cut an axial wall as in Fig. 353, and thus make a body of porcelain, giving strength at a weak point. This same cavity is sometimes so extensive that anchorage is made by wire pins or staples. In instances where the incisal section of the tooth has been lost by accident or decay, this process of retention is preferable and highly recommended for permanency. Fig. 354 shows a central tooth, a matrix, and the porcelain section with wire anchorage. This case shows loss of one-fourth of the tooth and the cavity made by cutting the dentin to the required depth, an operation possible with few exceptions. The enamel edges are made true by a flat stone, after which the matrix is made of the walls and edges, and shown without a floor. The wire is iridioplatinum, gauge 24, made in the form of a staple or loop, and inserted while the matrix is in place; with these in position, porcelain in paste form is pressed over all and excess moisture is absorbed by holding a napkin or bibulous paper to its surface. The combination is carefully taken from the cavity and fused, thus forming a base with a wire loop or pins held securely without soldering. This foundation is now placed on the tooth and matrix edges thoroughly burnished, after which the operation is completed by repeated fusing. When the matrix is removed the contoured tip will resemble the third

section of Fig. 354, and is ready for cementing. When the first porcelain is applied it will likely fill the loop, but this must not be corrected until after fusing, when the porcelain is easily broken away with blunt pliers. Frequently the staple or loop is inverted to suit conditions, but the form represented is the most durable in every particular. The difficulties

Fig. 354



of this operation are increased by the irregular form of fracture, for usually they extend lingually and frequently quite to the gum margin; a restoration of this kind should not be attempted until the operator has had considerable practice, for the making of an incisal tip acceptably is one of the most difficult operations.

Figs. 355 to 364 show cavities in biscupids and molars for porcelain inlays. The forms are very similar and directions for cavity technique are applicable in either instance. The value of porcelain in these positions

Fig. 355



Fig. 356



Fig. 357



is questioned because the force of contact is increased and the esthetic value is decreased. There are many exceptions, and the opportunities exist in mesial surfaces of superior biscupids and molars. The occlusion is the first consideration, size and depth of cavity are next, although the latter is generally regulated by a step as shown in the sketches. This step

is made of cement or gutta-percha and not of the same extent as if preparing for a gold inlay (Fig. 365). The gingival borders are more curved and the step is rounded and allowance made for greater thickness of

Fig. 358



Fig. 359



porcelain at the occlusal surface. The inlay will be more secure without a step or interior preparation with any other material, but bicuspid and molar cavities are usually too deep for successful matrix formation.

Fig. 360

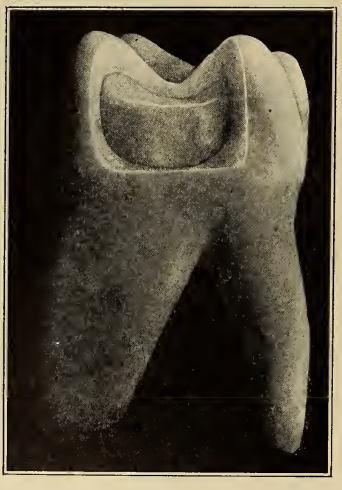


Fig. 361



If this can be accomplished, there still remains the difficulty of placing the inlay, because of greater bulk than it is possible to get space for; however, there can be no set rule, circumstances and good judgment

must be factors at all times. In any case the cavity must not extend into the sulci between cusps unless the sulci are of sufficient size to

Fig. 362



Fig. 363



assure strength of porcelain. Figs. 360, 362, and 364 show enamel surface edges without any extension to the sulci.

Figs. 365, 366, and 367 represent cavity preparation for gold inlays in molar and bicuspids, showing the locking or mechanical retention generally advocated. By this preparation it is possible to reduce the thickness of gold without interference with durability, and the amount of cement

Fig. 364



Fig. 365



required is also reduced to the minimum. Note the square edges and angular lines at the gingival border which is not permissible with a metal matrix, but wax in proper mouldable state will adjust itself readily

at these points. A chamfered edge is not incorrect in many instances; in fact, some teachers contend that this is a proper method. It would seem that a burnished edge is easier obtained when the cavity edge has a bevel; but it is one of those points frequently discussed, and the square

Fig. 366

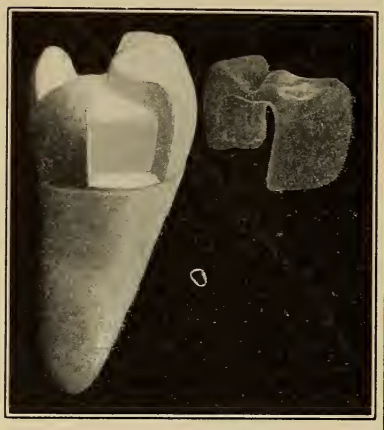
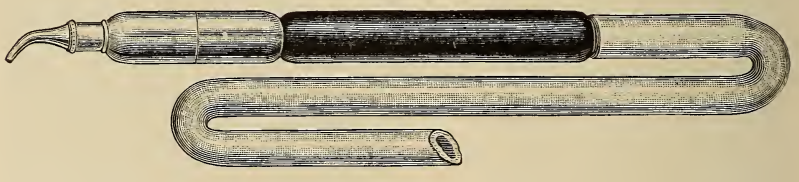


Fig. 367



edge and bevelled edge preparation have each an equal number of adherents. Fig. 366 shows a double compound cavity which is very common in bicuspids and molars and not always possible to restore by a casting in one piece. To draw the wax without change the axial walls must converge slightly toward the occlusal surface and the cavity walls having the same tendency toward the outer border. It is not expected that the locking or keying system shown in 365 and 367 can be used in every case or without variation. Many cases have insufficient crown for

Fig. 368



Roach's suction wax carver.

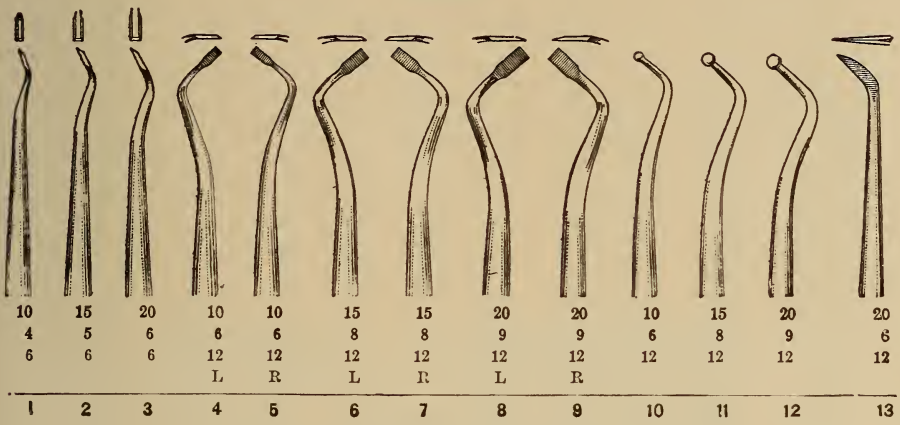
this application; in these a post or pins are recommended. Frequently there is considerable bulk of wax owing to certain conditions not always possible to avoid, which if reproduced in gold will increase the cost of the operation very noticeably. The wax can be reduced by melting the surface, which will be cemented. Considerable undercut can be made

which will increase retention of the inlay. The best instruments for this purpose consist of hollow points with rubber tubes attached.

The point is heated and applied to the wax, and sucking the tube will draw the melted wax into a small section filled with cotton. Electric points of various forms are also used, and the simpler method is a hot amalgam burnisher, wiping the wax from the point after each application.

The formation of cavities is greatly assisted by special burs and chisels of various sizes and curves.

FIG. 369



Simpson's automatic chisels (proximal).

FORMATION OF THE MATRIX FOR PORCELAIN

The difficulties pertaining to the making of a matrix are much reduced by having plenty of space between the teeth, and this must be obtained prior to the operation by means of tape cotton, or rubber wedges. Mechanical appliances may be used as an assistant when the inlay is made and the space for easy insertion is insufficient, but holding the teeth apart while making the matrix is usually an interference that can be avoided by giving this part of the work proper consideration. Room to work is a good rule to follow in any operation, but it is positively necessary with the inlay, because the mass is hard and unyielding with breakable edges. It must be placed while the cement is soft, and without delay, and the slightest interference may mean much loss of time and poor results.

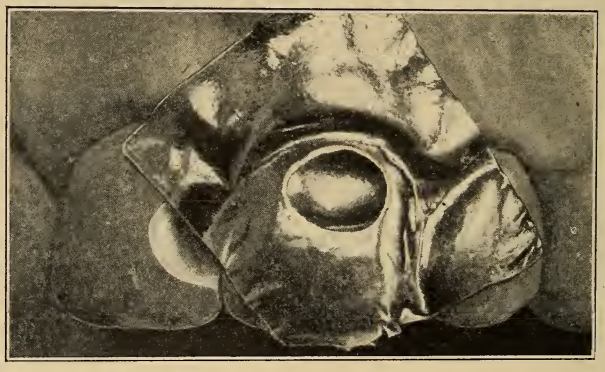
A gold inlay can be forced to place without damage, but an unpleasant experience or two with porcelain will demonstrate the desirability of having plenty of space.

The reproduction of the form of a cavity in foil for an inlay is called the matrix in which the porcelain is moulded by heating to a degree required to fuse the component parts of the material to a vitrified mass.

The metal most generally used is pure platinum foil, $\frac{1}{1000}$ of an inch in thickness. Gold foil No. 40 is also largely used, but only in connection with a low fusing porcelain which fuses at a temperature of 300° to 500° less than gold. Platinum has the advantage in the fact that it cannot be affected by any heat required to fuse the highest grade porcelain. It is not so ductile, or so easily moulded to form, but this disadvantage is counterbalanced by its stability, which allows greater freedom from care as to the changing of its form while filling with porcelain.

A gold matrix is invariably invested to prevent its changing form and protect it from overheat. This requires time and care, therefore platinum is more desirable from many points, and practice will assist greatly toward easy manipulation. There has been much discussion in the past upon the proper thickness, but it is now generally conceded that $\frac{1}{1000}$ of an inch will suit all cases better than any degree thinner or thicker. A thinner material has not the stretching quality, and anything heavier will cause a thicker cement line.

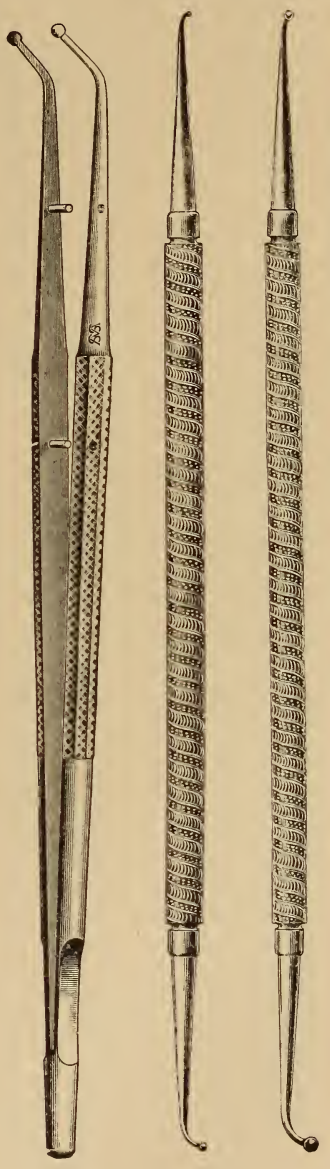
FIG. 370



A simple cavity on the labial surface of a central will serve to illustrate the mode of procedure, which is the cutting of a square section of the foil sufficiently large to extend over the adjoining teeth, holding the corners in the manner of Fig. 370, and while held securely by the fingers, press the foil over the cavity with some material such as spunk, cotton, small chamois disks, or a soft rubber point like a pencil end, and in this manner the cavity will be outlined on the foil and that portion covering the cavity concaved so there can be no mistake as to what portion is to be burnished. Then use ball-pointed burnishers of various sizes, such as amalgam instruments shown in Figs. 371 to 375, and gently rotate, gradually pushing the burnished surface to the cavity walls and floor, using care not to break the margins. The metal will probably split or break as it is forced to place, but unless extremely ruptured, it will not inter-

fere with final results. When the interior portion is fairly fitted, packed with spunk, cotton, or gum camphor, and held securely with a blunt instrument, a flat, blunt instrument should be used to get perfect margins. Then the packing is removed (except when using camphor, which is burnt out), the matrix released with very fine pointed pliers, and results noted.

Fig. 371 Fig. 372 Fig. 373



If satisfactory, the next step is filling the mould with porcelain.

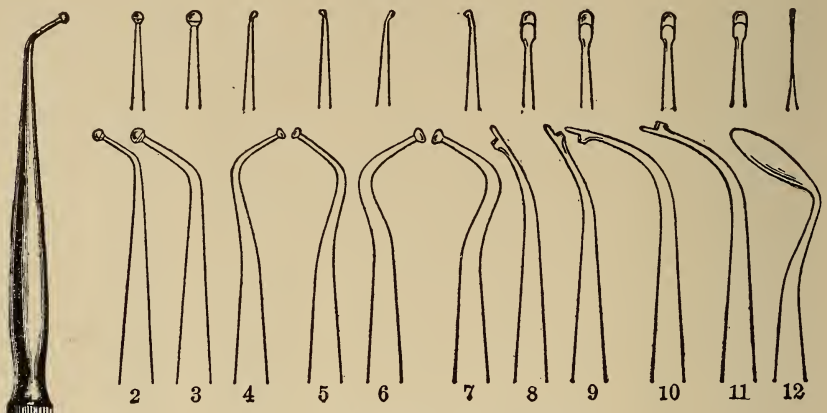
Platinum foil should be thoroughly annealed in the furnace muffle; the heat required to improve its softness is at least 2200° F. The foil purchased at the present time is usually ready for making the matrix, having already been thoroughly softened at a very high temperature. A matrix of complex character will require more than usual burnishing, which will have a tendency to make the metal harsh. It can then be re-annealed to advantage, providing the temperature is not less than the degree already mentioned.

An excess of material is recommended on labial cavities for the purpose of holding securely, but in other places the reverse is desired. Notably on proximal surfaces, where the excess will interfere with removal after taking the form of the tooth. Burnishing the matrix in proximal cavities, corners, and tips is greatly assisted by strips of either cotton, rubber dam, or goldbeater's skin held securely over the metal, insuring its proper position and preventing tearing on the sharp cavity edges (Fig. 376). Avoid lapping or folding of matrix on cavity edges.

After the matrix is made the next procedure is filling it with porcelain. This is done by holding the mould in straight, fine-pointed pliers, applying the porcelain with a fine sable pencil brush, or the end of a spatula made for the purpose (Fig. 377). The porcelain powder is mixed with pure water, distilled preferably, into a stiff paste, and after applying it is shaken to position either by tapping or drawing the serrated instrument handle across the pliers.

This jarring brings the moisture to the surface, and after tracing the cavity outline and removing excess with brush, it is laid face down on a clean towel, bibulous or blotting paper, which absorbs the excessive

Fig. 374



Reeves' set of inlay burnishers.



1

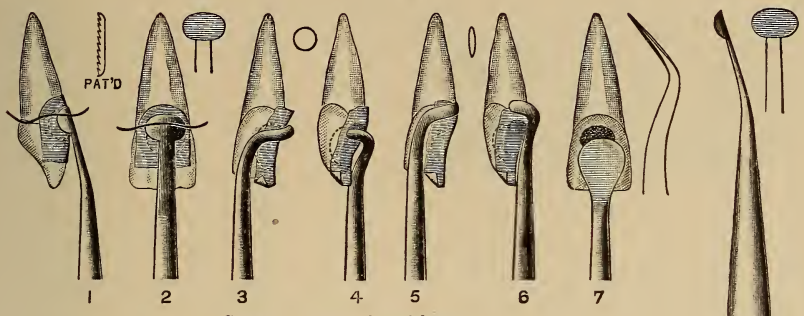
moisture. The inlay is then dried out in front of the furnace muffle, gradually pushed into the furnace, and fused. Too rapid drying will cause porcelain to jump from the mould. A high fusing porcelain mixed into a stiff paste will shrink about one-fifth its bulk, therefore a second or third fusing is required before the inlay can be called finished. If the porcelain is thin its proportion of shrinkage will be greater, and it will not bridge or carry its weight across any tear or aperture that may exist in the bottom of the matrix; and in deep cavities this condition is nearly always present, therefore it is necessary to always turn the matrix wrong side up and carefully note its condition. Clean off any excess with the brush and thus avoid a misfit, for it is impossible to remove fused porcelain without distorting the matrix or totally destroying the work up to this point.

The first fusing is usually called "first bake" or "biscuit," which is a stage wherein the component parts of porcelain are brought together by the heat and made into a hard, homogeneous mass without gloss.

It is at this stage that shrinkage is most apparent, and it is a condition that exists in every porcelain operation of whatever dimensions. Shrinkage is governed by quantity and quality of material and is a prominent factor toward success or failure. In small inlays shrinkage is of less import, but in proportion to size it must be dealt with. This shrinkage may be sufficient to distort the matrix or cause porcelain to attach to the matrix walls. As it is never consistent it is very important to control it, but this is only

possible to a small extent. Shrinkage toward the matrix wall is most desired and can be assisted by a slight cut or groove across its greatest

Fig. 375



Sausser's matrix burnishers.

extent, thereby giving the porcelain an impetus in that direction. In large spaces much assistance in controlling shrinkage is derived from using small particles of baked porcelain mixed with the unfused paste.

After the first fusing of the inlay the excess platinum or matrix material should be trimmed, leaving a working margin to allow a refitting in the cavity. In small, simple cases this may not be necessary, but in the majority of cavities it will assist greatly. If the matrix has become slightly altered by shrinkage or careless handling the change is noted at once and corrected. In contour work it will assist the eye to determine where to add or reduce; in fact, there can be only very small argument against a trial of the embryo inlay in its place and reburnishing the cavity edges.

Taking the shade is the first requirement, as the foundation should approximate the final shade, but after the inlay is reburnished this question must be settled in the operator's mind, and the final fusing proceeded with. First, clean off the inlay with a brush dipped in alcohol or warm water, thus removing saliva, blood, or any undesirable particles, then carefully fill any crevice caused by shrinkage or breakage, finally filling the matrix or building the contour or section as desired, always considering shrinkage. A second bake may be sufficient, but usually a third is required or even a fourth. Frequent firing is not harmful providing the porcelain has not been carried to a finishing heat previously. Shrinkage must be overcome, therefore withdraw the work from the furnace before it is fused and note its condition. (See Fusing.)

After the inlay is properly fired the matrix is removed by turning the metal back from the edge with pointed pliers, releasing the inlay. Fre-

Fig. 376



Fig. 377



Fig. 378



quently small particles of metal adhere to the porcelain. If a pointed instrument fails use a discarded bur, but in larger inlays small quantities of adhering metal will make no difference in any way. The inlay is now tried in place, having the cavity wet, which helps the porcelain to blend with the natural tooth, and at this stage the patient should be shown the results, for at a later period the cement and drying of the tooth makes a change not always satisfactory, but fortunately this is largely corrected by time.

The inlay is grooved or undercut by wheel disks such as hard-rubber, corundum, or copper coated with diamond dust. An additional retention is secured by using hydrofluoric acid. This acid has a great affinity for all vitrified surfaces, therefore great care is necessary that the outer and finished surface is thoroughly protected, and the most simple method is to soften the surface of a small piece of paraffin or beeswax, and embed the inlay face downward. Then cover the exposed surface with a few drops of the hydrofluoric acid, and after about five minutes wash with a spray of water.

The use of acid for this purpose is very common, and the tendency to carelessness is sometimes checked by a bad burn, which is always painful and very slow to heal. After the inlay has been subjected to acid it should be soaked in alcohol, which will soften the white scale, which is removed by scraping the surface with a sharp instrument, and thereby give the cement a better attachment to the roughened surface. This is a point not generally considered, but it is reasonable and practical, and many small inlays have been lost through non-observance of this fact.

As the inlay is now ready for inserting the tooth is dried and protected from moisture either by napkins or rubber dam. The latter is preferable,

but not necessary, providing the operator can use a napkin properly. Successful inlays depend upon perfect adaptation and cementation, but frequently the operation is spoiled through carelessness or a desire to hurry the case to a finish, therefore too much stress cannot be placed on this important part of the work. The cement shade should approximate the shade of the tooth and inlay, must be mixed thoroughly, and of creamy consistency and of medium to slow setting quality. Apply it to the cavity with a small spatula tip, then gently press the inlay into position, wipe off excess with spunk or tape, and note the line of demarcation. If this is satisfactory hold the inlay in position until the cement has commenced to harden, then protect from moisture by covering with melted paraffin, wax, sandarac varnish, or chlorapercha. If the inlay is extensive it can be ligated with floss silk or held by a wedge, always avoiding the use of excessive force, or the delicate porcelain edges will shatter.

A later sitting is required for a final finishing, for the best of inlays will need smoothing of edges, which is done with small stones or sandpaper disks and strips.

LOW FUSING PORCELAIN

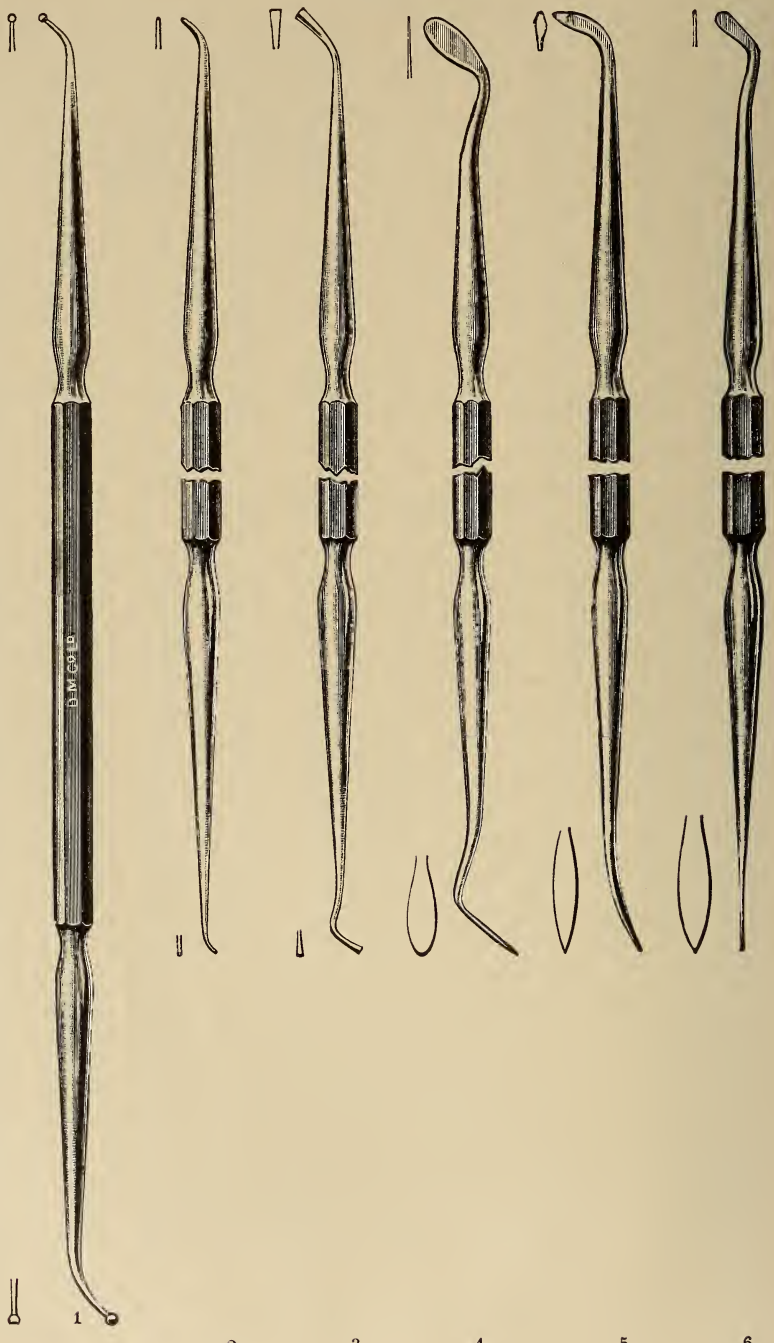
Having described the process of making an inlay with the platinum matrix and high fusing porcelain, the next consideration will be the modifications necessary when low fusing porcelain is melted into a gold matrix, therefore the method as described by Dr. J. Leon Williams[1] is herein inserted, and is as follows:

"The thinner the gold can be used the more perfect the fit of the finished inlay. A proper set of instruments for shaping the gold form and for manipulating the porcelain paste is an important matter. I have devised for these purposes the set of instruments shown in Fig. 379. They are all double-end instruments. Nos. 1, 2, 3, and 4 are designed for fitting the gold form to the cavity, while Nos. 5 and 6 are for manipulating the porcelain paste. The gold should be cut out to represent roughly the shape of the orifice of the cavity, but considerably larger. Fig. 380 shows the proper shape for such a cavity as is shown in Fig. 381 at *a*. It will greatly facilitate the shaping of the gold form if a notch be cut out of the gold as shown in Fig. 380, and at the same time decrease the chances of breaking through the gold in forcing it into the shape of the cavity. It should first be introduced into the cavity without annealing. The cut edges will then slide over each other as the centre of the gold is forced to the bottom of the cavity. . . . Then, with the cotton or spunk tightly packed in the cavity, take instrument No. 2 and most carefully burnish the gold around the entire edge

[1] Dental Cosmos, November, 1899, vol. xli, p. 1087.

of the cavity. This instrument will be found well adapted to reach every part of the margin. It will generally be found best to hold the

FIG. 379



cotton-wool back a little from the margin of the cavity when one is burnishing, with an instrument held in the left hand, and with this instrument (preferably a ball burnisher) also press the cotton-wool well into the cavity. This holds the gold form well in place and prevents rocking while the edges are being burnished.

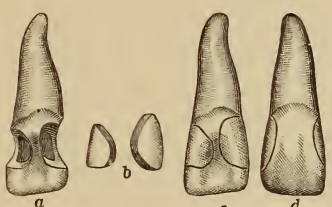
"Most operators have found the removal and imbedding of the gold to require the most delicate manipulation, and by the methods heretofore described one is never quite certain whether or not this part of the operation has been successfully performed until the inlay has been completed and tried in place. All of this uncertainty may be avoided by the following procedure: Slightly warm and roll up in the fingers a small ball or pledget of hard white wax, such as is supplied for crown-work and bridge-work. The ball of wax should be just a little larger than is necessary to fill the cavity completely; that is to say, it should *slightly* project over the margin of the cavity all around. The wax should be

FIG. 380



Sheet of gold or platinum, notched and ready for adaptation to cavity.

FIG. 381



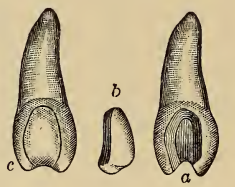
Right superior central, showing two large proximal cavities to which access is obtained by cutting freely from the lingual walls: *a*, tooth with cavities prepared; *b*, porcelain inlays for same; *c*, tooth showing lingual surface; *d*, labial surface after cementing of inlays.

quite stiff when introduced into the gold form as it lies in the cavity of the tooth. Now take the broad, thin burnisher, shown in No. 4, Fig. 379, and press the ball of wax firmly into place. To prevent the burnisher from sticking to the wax, it should first be dipped into French chalk or pulverized soapstone. In such cavities as are shown in Fig. 381, at *a*, broad polishing tape, dusted with French chalk, may be used for pressing the wax ball into place; but great care should be exercised not to pull the tape the least in one direction or the other, as one would do in polishing a filling. This would rock the gold form and mar the fit. The pull should be steady and equable from both ends of the tape, the object being to press the wax everywhere firmly over the edges of the cavity. A stream of cold water should now be thrown on the wax, and then the wax and gold form should be quickly removed. If this part of the operation is done with ordinary care, the finished inlay will always be found to fit perfectly. To facilitate the quick removal of the form, care

should be taken to prevent the wax overlapping the gold much at any point outside the margin of the cavity. To prevent this and also to assist in securing proper embedding of the gold matrix, it is well to let the margin of the gold project as much as possible beyond the edges of the cavity.

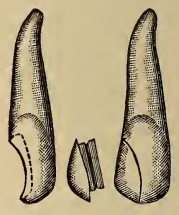
"The matrix may now be embedded without the slightest fear that its shape will be changed. For embedding material I use plaster and marble dust. When the investment is sufficiently hard the wax is thoroughly melted out with a stream of boiling water. The investment is then dried and brought to a full red heat with the blowpipe. It is then allowed to cool, and is ready for packing. Now, the first step in the packing of the porcelain paste is the all-important one to prevent the porcelain shrinking away from the walls of the matrix. This may always be accomplished easily with porcelain of any make if the following instructions are carefully observed: Mix the porcelain paste to the consistence of soft putty, and with the upper point shown in No. 6, Fig. 379,

FIG. 382



Showing bicuspid with cavity involving proximal and grinding surfaces: *a*, tooth with cavity prepared; *b*, porcelain inlay; *c*, inlay cemented in place.

FIG. 383



a *b* *c*

Canine tooth showing at *a*, large cavity, and at *b* and *c*, large porcelain inlay restoring contour of tooth.

place a ring of this putty around the entire circumference of the cavity leaving the centre quite free or empty. In melting a porcelain paste it naturally shrinks toward the largest mass of its own body, or toward the centre of the mass. If, then, this centre be removed we should naturally expect the mass to shrink *toward the circumference*, and this is precisely what happens when manipulated as directed. The matrix always comes out from the first baking with the porcelain everywhere firmly melted to the walls of the matrix. Nor will it start from this position at any subsequent baking unless it is very much overheated.

"After each packing of the porcelain paste, a small camel's-hair brush with a fine point should be moistened (this is best done by drawing it between the lips after the manner of water-color artists) and drawn around the margin of the matrix to remove all overhanging particles of the paste. If this be not done, the margins of the inlay will often be found ragged, and a perfect margin is the most essential feature of a porcelain inlay. If gum water be used for mixing the paste, it will be

found necessary to remove these overhanging particles with great care, as the tendency naturally is for the gum water to cause the particles of powdered porcelain to stick to the gold or platinum margin of the matrix. In building up the inlay for restoring lost corners of teeth and for general contours the work will be much facilitated if, after the first baking has been carried through as above described, to secure perfect union with the walls of the matrix, a small piece of solid porcelain be placed at the point representing the highest point of the contour of the inlay. These pieces of porcelain may be made by crushing old porcelain teeth in an iron mortar. Care should be taken to use a piece small enough so that the outer edge will not show through when the inlay is completed. Corners like the one shown in Fig. 383 may be produced in this manner without much difficulty."

CEMENTS AND MANIPULATION

What cement do you use? is an ever present query in all porcelain discussion, for when there is a failure the cement is generally blamed for it. This is a natural deduction when it is considered that a student in porcelain is more familiar with cement than with other parts of the operation, and if there is a failure it is a natural supposition that it is caused by poor material. A cement must be tenacious, finely ground, and not quick setting, and of a quality most likely to resist moisture when setting, for it is not always possible to keep the work free from dampness during that important stage. There are many cements manufactured that have these requirements, and, like other materials with similar merits, the choice rests with the operator. They all have the same disadvantage, viz., opacity, and the perfect porcelain operation cannot be claimed until the attaching medium is transparent, or nearly so. The newer silicate cements were thought to have this virtue, and many were deceived into using them, but it was found that the tenacious period was of short duration and the inlays loosened, causing much disappointment. A common trouble is mixing cement too thick, thus preventing proper seating of inlay, which makes the joint conspicuous and unfinished. When this occurs quickly remove and cleanse every part thoroughly, replacing with a thinner mixed material.

Shading.—This part of making porcelain inlays is the most difficult to the majority, and is an uncertainty with all of us. The problem of shrinkage is an unknown quantity, and its remedy is purely mechanical, but the problem of shading is a combination of various considerations which may be followed most minutely and then the object may be defeated by some detail not always possible to avoid, and this most common defect is caused by the opaque cements. The most experienced have this discouragement, but it can be decreased by using a variety of shades and matching carefully. We have and can mix an

almost endless variety of porcelain shades, but this is only a part of the requirement, for position and tooth density must also be considered, together with quantity or size of porcelain to be fused. There is also the additional difficulty of correct fusing to reproduce the desired shade.

Overfusing is the cause of more shade failures than any other, but practice will largely obviate this trouble as in other difficulties. The most careful directions are inadequate as compared with actual demonstrations. When the best has been said, there is still the impossibility of reaching all understandings, because this part of the subject appeals directly to the artistic sense, and can only be comprehended through observation and experience.

The difficulty of obtaining colors that accurately match the natural teeth is a part of inlay work which will always be perplexing, for the teeth are largely composed of organic matter, while the material used for repair is an inorganic composition, differing in texture and density. When selecting the colors for inlays, note the various shades of the natural tooth, for frequently there are three or more. If the tooth is vital these hues have a distinction which is lost after devitalization, thus increasing the difficulties of matching but if the variant and uncertain hues of the pulpless tooth are once reproduced in an inlay, the subsequent change attending the cementation is not so marked because of the pulpless tooth opacity.

Position of the inlay is a factor which largely governs the shade, for the shadow problem is an incident which forces consideration also. This is particularly evident in proximal cavities, and is remedied to some extent by making the inlay a shade lighter, and is also controlled by the size of the inlay. A lateral incisor being much smaller than a cuspid must be treated accordingly, for the density of the latter is much greater and will allow a deeper shade. Labial inlays, particularly bordering the gingival line, can safely be made a shade deeper; but due consideration must be given to depth, for if very shallow, the porcelain should be of greater density and thus overcome the cement change. Inlays of this kind are improved in texture by using nearly all base body, and in some instances low fusing porcelain is more effective because of its less translucency.

With one exception all inlay porcelains are of the same texture from base to finish, which is an advantage in the instance just cited, but the introduction of a combination consisting of a basal body to be covered by enamels was a step toward procuring more natural results in the majority of cases. This basal body represents the dentin, which in turn is covered by a more transparent material representing the enamel, thus enabling the operator to blend the various hues of shade of which the natural tooth is composed, thereby producing a translucent effect not possible by one dense porcelain no matter how expert the operator may be.

The restoration of an incisal tip or corner is an operation that requires much practice and artistic skill, for its prominence demands perfect shading and adaptation. An operation of this character, while testing the ability to shade, has the advantage of not being affected by the cement line because of greater proportion or volume of porcelain. However, perfection must not be expected because there is always the difference between the natural translucency of tooth structure and the unavoidable density of porcelain which in certain positions is more noticeable by the deflection of light rays.

A common mistake in shading is in not considering the difference between the volume of shade exposed on the porcelain shade guide and the quantity required to fill the cavity.

The mixing of several shades to gain the one desired is largely one of intuition, because that shade cannot be known until properly fused. This difficulty is unfortunate, but cannot be avoided, as all porcelain powders are practically the same, with the exception of a few extreme shades, and herein lies the difference between the porcelain artist and the painter whose pigments are mixed and the desired shade revealed to the eye by simple manipulation.

Fusing.—It is generally conceded that fusing porcelain is one of the greatest difficulties that must be overcome before the novice can feel that he has made any advancement toward the successful making of an inlay or anything in which porcelain is the component part. It is an indisputable fact that this part of the work is a veritable stumbling block, and the cause of much discouragement which is only overcome by persistent practice, for without this necessary knowledge successful results are not possible.

Porcelain may have a fusing point as low as 1600° F., and varying to 2600° F. or even higher, therefore the operator must become familiar with these varied heats and their productions. This will mean continuous applications and training the eye to the various stages and changes of the material. Using a timepiece with a pyrometer will be of great assistance, but the personal equation is always the dominant factor, and herein lies the difficulty of giving directions that will be accurate under all conditions. Before the advent of the pyrometer the eye was the only test of heat, therefore to the beginner this device has considerable value, together with the fact that the fusing point of the numerous porcelains is known. Thus a certain time by the watch with the fusing point of the porcelain already known and the pyrometer showing the temperature, the fusing of porcelain seems comparatively easy. Various sizes of porcelain require different heats, therefore it is absolutely necessary to know porcelain in all its changes, without any assistance whatever, otherwise the work will be either over- or underfused, and only by chance will it be correct if the machines are depended upon entirely. There can be no difference of opinion on this fact, therefore the best

equipment is the personal knowledge which makes one independent of any appliance or set of rules and regulations. It is generally contended that exposing the eye to such severe changes of light is injurious, and this may be true beyond a certain point, viz., 2300° F., a temperature sufficient for the majority of our porcelains. There is a product by a well-known firm which requires a heat of 2600° F., and there is no doubt that the eyes should be protected from the glare of this heat, which is unnecessarily high, especially for inlay work.

As electric furnaces are most commonly used for fusing porcelain, it is not very difficult for the student to become familiar with the various changes of heat as regulated by the rheostat, and thereby know what step will fuse a certain known product. For instance, the first step on the majority of furnaces will fuse a low fusing body of 1600° F. in probably one minute or even less, but the same heat will fuse a much higher porcelain if given longer time. Then, again, voltage must be considered, for in many cases it is only approximate, sometimes varying three or four points less or that much more, and still coming under the class of 110 volts direct. This fact is particularly noticeable in local establishments such as office buildings. The alternating current is usually more even, and that of 220 however being very strong and harder on the furnace muffles.

The best fusing is obtained by inserting the porcelain at the lowest temperature and gradually and slowly raising the heat until the fusing point is obtained, thus passing the material through its various stages of condensation. These stages are called "biscuiting," and a porcelain partially fused may be called a medium or hard biscuit. In the latter condition the porcelain has a half glaze and has shrunk to a solid mass and is ready for the additional material required to give form. Then the porcelain can be fired until it has the finished gloss, which is determined by the eye of the manipulator. The best results are always obtained by underfusing the first bake, because several high heats will overfuse the groundwork which reduces its strength and solidity. Using a porcelain of slightly lower fusing point the finishing will obviate this tendency, which is detrimental to the whole work.

As an instance of this, note a manufactured tooth which is finished in one baking, and the same directions are applicable to carved teeth for special cases. A student will readily learn what is a proper glaze required if he will take any plain or plate tooth and apply porcelain to its surface and watch the various changes until his material has reached the same condition. This simple experiment will also help him to recognize the heat required for these changes and ultimately enable him to acquire self-confidence in the management of the fusing process.

Porcelain.—Porcelain bodies made for inlay purposes are to be had in great variety, both in fusing point and texture; in fact, there is such a number for choice that the unexperienced must necessarily be bewildered;

however, this difficulty will settle itself like many others that may at one time have been just as perplexing.

For many years there was much controversy regarding the qualities of various products, particularly between the advocates of a high heat porcelain and those of low fusing qualities. While this question is still debatable, it is an indisputable fact that in America porcelains of the higher grade have the preference. This may be from the fact that the manufacturers of artificial teeth in this country have always used a high fusing material, and as the product has stood the test of time it is only natural to apply this argument to the inlay question.

English tooth body fuses about 400° F. lower than the highest fusing American body, which places the English on our list as a medium fusing material, and its excellent quality is indisputable; in fact, the majority of our inlay bodies are really a medium heat, ranging from 2150° F. to 2300° F., therefore the difference between this fusing degree and that of low body of 1600° F. or thereabouts is the point of argument.

When porcelain inlays were introduced the standard material was the continuous gum bodies then well known to porcelain workers and put on the market for their use. It was the only material to be had, and while it possessed the required quality, it had no variety of shade. After some years this was remedied, and the advent of the pyrometer enabled us to learn the approximate fusing temperatures of the old continuous gum bodies which were found to be about 2300° F. These bodies have not been much improved upon either in quality or finish. The first low fusing material was introduced in 1892 by Dr. Downie, but was not satisfactory for inlay work because of its poor shades, although it was quite extensively used for crowns. A few years later Ash & Sons made up a small assortment much improved in shades. Dr. Jenkins introduced his low fusing enamel in 1898. After this date manufacturers of porcelain produced an assortment suitable to all circumstances.

The wearing qualities of various porcelains are practically equal in certain positions, notably in cavities not extending to incisal edges or masticating surfaces, and in shallow labial cavities. Low fusing porcelain has an advantage from the fact that its opacity prevents the cement from changing the shade, which is frequently the case with a high fusing and more translucent body.

Workers of higher fusing porcelain will be more or less conversant with all porcelains and their variations, because this field is greater and has practically no limitation; but a low fusing porcelain worker is usually at sea if not using that material, while anyone accustomed to the higher heats can fuse the lower, providing care is used not to overheat. Too much heat is fatal to low fusing body, as it means not only loss of shade, but also loss of strength. The same rule applies to all porcelains, but not to the same extent if the porcelain is high fusing,

for its working latitude is much greater. Low fusing material is usually moulded in a gold matrix which is invested. Platinum must be used as the matrix for higher heat porcelains, and no investment of it is necessary.

As pyrometers are commonly used, a few of the most popular bodies, and approximate fusing points will assist the student, bearing in mind that these figures are based on two-minute tests, with conditions favorable for accuracy.

Low fusing.

Ash & Sons, 1550° F.
Jenkins, 1550° F.
Downie's, 1550° F.
Brewster's Gold Matrix, 1800° F.

Medium fusing.

Brewster's Enamel, 2080° F.
S. S. White's Medium, 2100° F.
Ash & Sons' "High," 1900° F.

High fusing.

S. S. White's Inlay, 2300° F.
Close's Continuous Gum, 2300° F.
Whiteley's Inlay, 2200° F.
Whiteley's Inlay special, 2400° F.
Brewster's Foundation, 2200° F.
Consolidated Inlay, 2600° F.
Johnson & Lund's, 2500° F.

Furnaces.—The advancement in the matter of furnaces has been so rapid that less than thirty years ago the user of porcelain depended on such an apparently crude appliance as is shown in Fig. 384 (old coke furnace), and yet the beautiful porcelain dentures and carved work of the older dentists has not been surpassed.

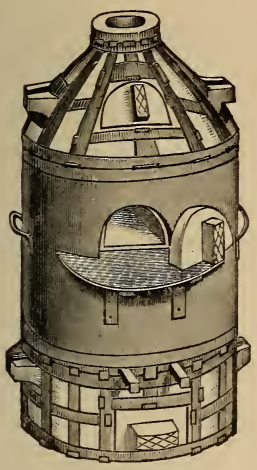
It was early recognized that a small, quick heating appliance was a necessity, and this difficulty was solved by Dr. C. H. Land by inventing the first gas furnace in 1886. This machine, while a great improvement, was slow and tiresome, as the constant use of bellows was necessary for half an hour before the furnace was hot enough for use. A smaller and quicker gas furnace succeeded this, more applicable for inlays and crowns, and was successfully used until superseded by electrical outfits, which have the advantage of cleanliness, purity, and noiselessness.

A gas furnace is noisy and gives much trouble in carbonizing the porcelain, or as it is usually termed "gassing." Fortunately, that is a discouragement of the past, for electricity has reduced fusing cares to the minimum. Other furnaces of that time were the Parker-Stoddard, Downie, and Fletcher.

Dr. L. E. Custer invented the first electric furnace in 1894, and while it was a distinct improvement, there was much trouble in muffle wires burning out, which caused much delay and retarded the general use of this class of furnace. The Custer electric furnace as now perfected is practically useful, and is a strong favorite. Five years later the Hammond (Fig. 385) was patented, and immediately became popular from the fact that a "damaged" muffle could be replaced immediately.

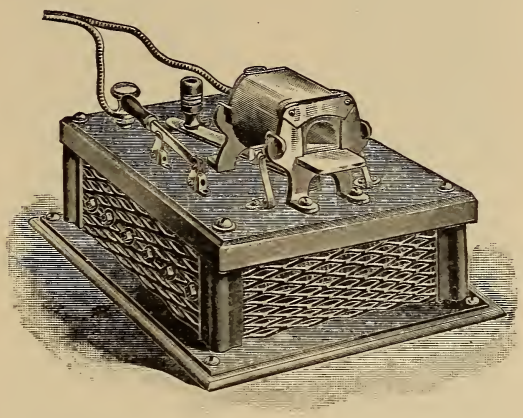
This furnace has remained a favorite until the present time, but is being gradually replaced by the S. S. White Co.'s new furnace (Fig. 386),

Fig. 384



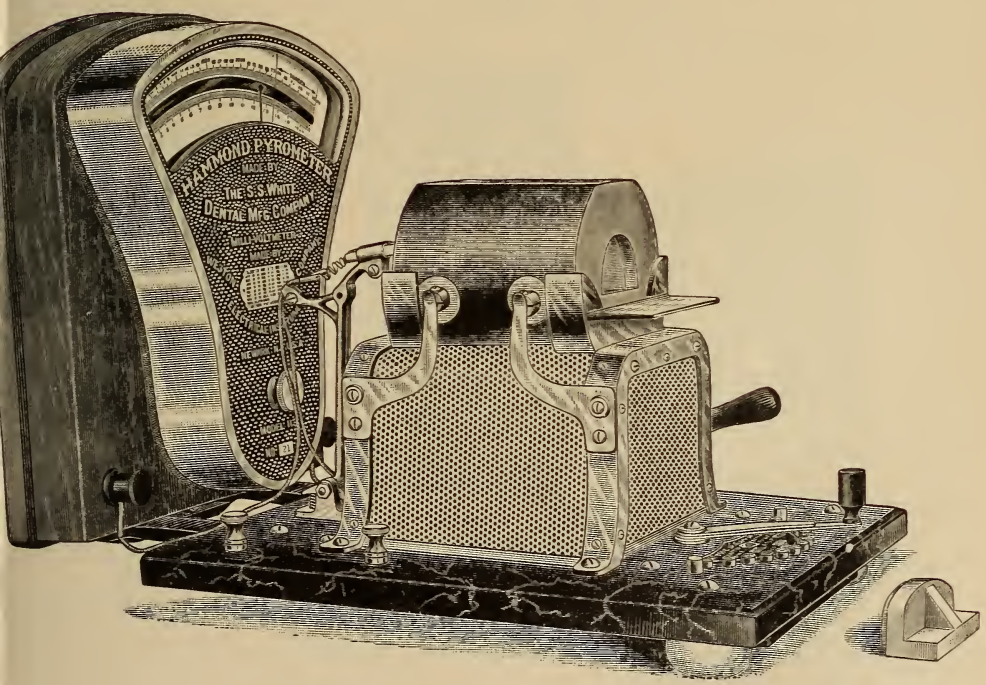
Old style coke furnace.

Fig. 385



The Hammond furnace No. 1.

Fig. 386



S. S. White furnace with pyrometer attachment.

which is similar, but improved in certain details, and it is also arranged with pyrometer attachment.

In 1902 the Pelton appeared. Besides these furnaces there are several others distinct in form, and all, with few exceptions, have a pyrometer attachment. They are: the Fletcher, Peck, Gerhardt, and Roach, and others including the Price, which has been withdrawn, although Dr. Price was the first to apply the pyrometer.

In addition, furnaces are slso made for gasoline use. The principal types are the Turner and Brophy. They are of great value to the out-of-town dentist, because they not only fuse porcelain, but have equal facility in blowpipe work and metal heating, thus enabling those not possessing gas or electricity to be practically on the same footing with the city practitioner.

GOLD INLAYS

Gold Matrix Inlays.—Gold matrix inlays have been used to advantage for many years, but the casting process has largely supplanted this process, therefore a description of these difficult and extensive operations must be considered unnecessary in this day of later improvements. It is an erroneous idea, largely prevalent in the profession, that matrix

FIG. 387 FIG. 388 FIG. 389







Cavities and restoratives suitable for and illustrating the gold matrix inlay method.

gold inlays are entirely out of date, for there is no doubt of this work still having its place and that it is applicable and successful under certain circumstances. Its chief recommendation is the saving of much valuable time. One predominant reason why the matrix inlay does not appeal to the general dentist is that phase of the operation which is the first consideration, viz., the making of a matrix. Having that knowledge,

the rest of the operation is so simple that very little practice will accomplish most satisfactory results.

Fig. 390



Fig. 391



Fig. 392



The process of making gold inlays is recommended for use in various positions where much contouring is not required, such as proximal cavities in bicuspids and molars, extending slightly between cusps.

Fig. 393



Fig. 394



Fig. 395



Cavities and restoratives suitable for and illustrating the gold matrix inlay method.

Occlusal surfaces between cusps, shown in Fig. 387, buccal cavities on same teeth (Figs. 388, 389, and 390); and small corners and incisal tips on anterior teeth which preclude the use of porcelain (Figs. 391 to 395).

In these latter positions the proof of the advantage of this work is the fact of the success of the method when every other material had been tried and failed after short use. An expert gold operator may not treat this assertion seriously, believing that a hammered gold filling will be equally successful.

In many cases, particularly in hard structured teeth, this is quite possible, but in frail teeth the application of this kind of inlay is simple, safe, and satisfactory, and saves time.

The procedure for this work is to make a matrix of the cavities as for porcelain, either in platinum of the same gauge or gold of No. 30 foil, with the difference that as the matrix will remain part of the filling, it is not necessary to burnish or stretch the foil to position. It may be carried to the bottom and walls with no attention to folds or creases, but the edges must be well defined, as in porcelain work. When the matrix is made and while still in the cavity, matt or sponge gold of any description is loosely packed into it and in sufficient quantity to support the walls and cover the floor and the break in the matrix which is then removed and two or three small pieces of 22 k solder applied to the soft gold and melted with the blowpipe (Fig. 396). The solder will run into the gold to the matrix walls, thus making the whole piece rigid. The excess matrix may be removed if so desired and replaced in the cavity and thoroughly burnished; it is again removed and with a fine pencil brush liquid rouge is traced over the whole outer surface to the cavity margin. This must be carefully done, for the slightest irregularity of the outline will be reproduced by the gold. The tracing of the liquid rouge prevents the gold from flowing beyond the margins, therefore it is a good rule to coat the underside, particularly if the matrix is of gold foil. Small pieces of solder, or pure gold if so desired, are then dropped in connection with the cavity and melted with the blowpipe. After the desired form is secured the excess matrix is cut away and the inlay is ready for treatment, as already described into casting process.

Fig. 396



Rowan's decimal gold No. 30 for packing the matrix has an advantage over matt gold because it is composed of a thin layer of platinum between two layers of gold, therefore it is only necessary to throw the flame on this combination while it is in the matrix and the gold portion immediately acts as a solder which unites the whole without any additional solder. This combination should be used only with a platinum matrix, and in any case the rouge should not be applied until after a trial fitting, because the burnishing will carry the tracing from the edges to the interior and prevent the solder flowing easily.

Cleanliness and care will obviate much trouble, for gold will not flow where there is the slightest deposit of rouge. Small tips and cor-

ners are contoured by the use of small pieces of gold plate cut to desired shape or melted into small globules, which extends the contour; these are afterward ground to shape. A little practice will insure very satisfactory results.

The Cast Gold Inlay.—There have been many inventions in dentistry, but it is doubtful if any improvement was ever received with greater enthusiasm than that of the inlay casting method.

Dr. Wm. H. Taggart, of Chicago, has the distinct honor of being the inventor of the first appliance for this purpose, having demonstrated its possibilities before a meeting of the First District of New York, in January, 1907.

For twenty years the profession had been gradually accepting the inlay in its various forms, also the fact that a cemented filling had merits worthy of consideration, therefore this newer and more perfect process was received without reservation, with the result that almost every dentist is a practitioner of this method. The almost unlimited possibilities of the casting process has developed newer operations almost too numerous to mention, including inlays of all forms, crowns, and various bases for such work, cast bridges, partial and full plates, dental splints, and various appliances. In fact, the ingenious dentist has by no means exhausted its possibilities of practical application.

The machines for performing this work have rapidly multiplied in design, and they are made in such variety of form and cost that no one need be dissatisfied.

Casting molten gold in various forms can be done in a myriad of ways, but the basal technique is the same in all instances, therefore the description as given by Dr. Taggart is necessarily authoritative, and is as follows:[1]

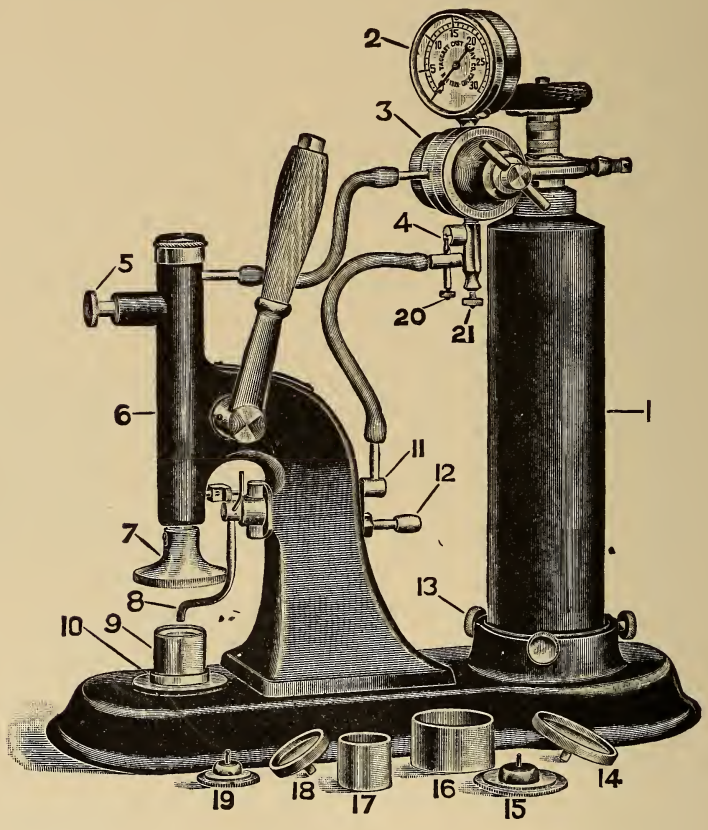
"In all my casting work, whether operative or prosthetic, I am using a special wax known as 'Taggart's Green Wax.' This wax has been made green in color because it will thus be easy to differentiate between the wax, the enamel, and the gum tissue when working directly in the cavity; and while most excellent results may be obtained by taking impressions and making amalgam or cement replica models of cavities, manifestly no duplicate of the cavity, and no articulated model thereof, can be so accurate as the cavity itself and the patient's jaws, which must give the exact occlusion. A little practice will convince the majority that it is better to work within the mouth when making inlays.

"This wax is warmed in water not above 138° F. until it is thoroughly softened throughout the mass. It must not be warmed with dry heat, nor manipulated with the fingers, with the idea that the softening can be hastened in that way. A piece the size of the stick and of length in proportion to the size of the cavity should be softened and carried in its

[1] Items of Interest, April, 1908.

original form to the cavity, and firmly pressed into the cavity with the fingers, allowing the excess to act as a piston in forcing it into all parts of the cavity. The patient should then close the jaw, biting firmly into the wax, giving the imprint of the opposing cusps. Then have him move the jaws, as in the act of chewing gum; this wears down all the high points and gives the correct occlusal form. All excess wax is trimmed away and the wax carved into the exact form desired for the completed inlay. A special quality of the wax is that it can be beauti-

FIG. 397



fully carved, remaining hard enough for this purpose even at the temperature of the mouth; and as the process exactly reproduces every form and line of the wax model, and as wax is more easily carved than gold, it will repay the operator to spend a little time, care, and artistic skill in making the wax model. The wax inlay remains hard enough in the mouth so that it may be lifted from the cavity without change of form, and it can then either be held in the fingers for further carving, or artistic touches may be added when the wax inlay is mounted on the sprue, as in Fig. 398.

"When finished the wax inlay is held in the left hand and the sprue wire in the right. Then heating the sprue wire until it will melt its way into the wax, the two are brought together, as shown in Fig. 399.

FIG. 398

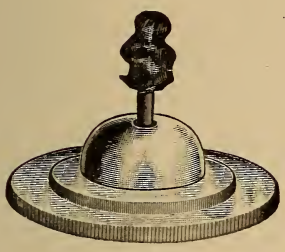
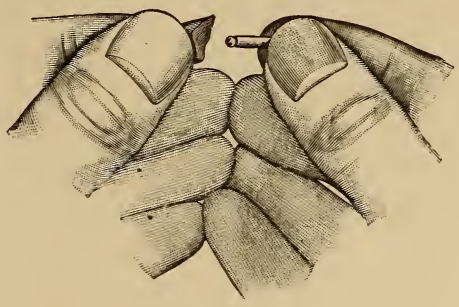


FIG. 399



"The inlay and sprue wire are then placed in the crucible former, as in Fig. 398. The investment is properly mixed in the following manner:

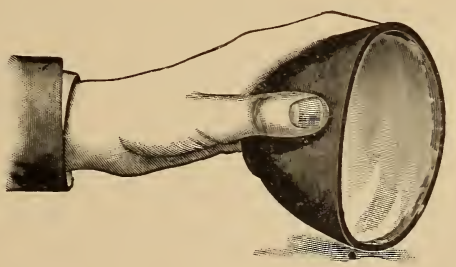
"The large cup on the measuring device (Fig. 400) is to be filled lightly with investment and scraped off flush with a straight-edged, silver-plated dinner knife, which can be used as a spatula.

FIG. 400



"The small end of the measuring device (Fig. 400) is filled even full with water and the two mixed together. For the large flasks just double these quantities. Then place the rubber plaster bowl in the position shown in Fig. 401, and jar it on the bench, rotating it slowly

FIG. 401



in order to smear the whole inside of the bowl with a thin layer of investment. This allows all air easily to work out through this thin layer. Carefully place the investment on the inlay in such a way as

absolutely to avoid all air bubbles being caught in the investment, because these air spaces would be filled with gold in the casting.

"This stage is represented by Fig. 402. Apply the flask, round edge down, and pour the investment until the ring is full. Do not jar the investment to make it go to place; this only causes the contained air in the investment to form large bubbles against the wax. Rotate the flask slightly and cover, and the mass will settle; then, if necessary, add more investment and turn the flask over on to some smooth surface and press the excess to place, allowing the excess to squeeze out of the small hole in the flask. The investment should be allowed to set for at least fifteen minutes, or it can be set aside for an indefinite period; but better results are obtained by drying out as soon as the plaster has set. When ready for casting, the crucible former is removed, as in Fig. 403, the flask is set over the Bunsen flame, and at first slowly dried out; as soon as the steam ceases forming a higher heat can be turned on and the wax burned thoroughly.

FIG. 402

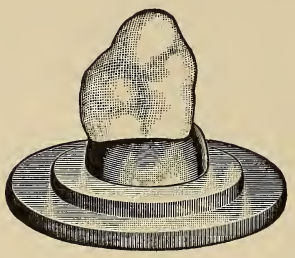
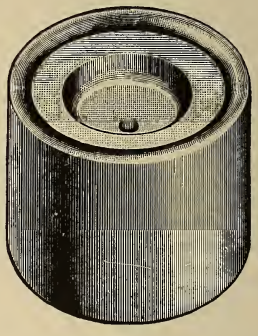


FIG. 403



"It is now ready for the casting machine, and a generous button of 24 k gold, at least five pennyweights, should be placed in the crucible. As there is no waste in casting, it is always best to have plenty of gold in the crucible.

"Referring to Fig. 397, the machine is operated in the following manner:

"The flask 9 is placed in ring 10. The city gas is connected by hose to 12. The nitrous oxid blowpipe 8 is turned at right angles to the machine and the city gas lighted, making a smoky flame about four inches long. The handle to the reducing valve 3 is turned backward, or to the left; now open, with the wheel, the main nitrous oxid cylinder valve 1. This allows the high pressure of the nitrous oxid gas, which in a full cylinder is one thousand pounds, to pass into the reducing valve 3, and by turning the bar handle of the reducing valve 3 to the right, any degree of pressure can be indicated on the gauge, although five to eight pounds is sufficient. The needle valve 21 is opened to allow nitrous oxid to flow through 11 to unite with the city gas, which comes in at 12. By

mixing the proper proportion of nitrous oxid with the city gas a blue flame is made about three-quarters of an inch long. Now place the flask 9 in the machine ring 10, using the tongs; then turn the blowpipe to the proper position to play on the button of gold, and when the gold is in a boiling state, bring the handle forward with a decided jerk, which will automatically throw the blowpipe 8 out of the way, and automatically bring the pressure plate 7 down airtight on the flask 9, and automatically hold the lever down by closing the lock 5, and automatically start the alarm whistle 4, which is regulated as to its volume of sound by the small needle valve 20. The object of this alarm is to draw attention to the fact that the main valve on the nitrous oxid cylinder 1 is to be shut off when the casting is finished, or the nitrous oxid will escape over night. The sustained pressure should be kept on top of the gold for thirty seconds, after which the flask can be taken out and put into water, when the investment can be washed off. The inlay should now be placed in 50 per cent. hot hydrochloric or full strength hydrofluoric acid, to make certain that all foreign investment is dissolved off.

"The excess gold is sawed off at the sprue and the filling mostly finished out of the mouth. It is always best to examine the cavity side of the inlay under a magnifying glass so as to see that there are no little beads of gold, which would prevent it going thoroughly to its seat. As these fillings fit the cavity so tightly, it is best to drive them to place several times with a stick and mallet before setting, and when the cement is in place, seat again with mallet and stick.

"This repeated tapping with the mallet in different directions will seat an inlay better than it can possibly be done by direct pressure on the inlay. The margins can now be gone over with stones and disks of polishing tapes and finally polished. When prosthetic pieces are being made, Taggart's green wax should be kept at a workable temperature by frequently holding the model and wax in water at 138° F.

"The possibilities for displaying ingenuity in constructing different prosthetic pieces are only limited by the versatility of the dentist.

"The nitrous oxid blowpipe for this work has decided advantages over any other blowpipe flame, for the reason that the gold can be melted so much more readily, and brought into a more fluid condition and shot into the mould while the mould is practically cold, and not unduly expanded, as the investment would be if the gold were melted by the ordinary blowpipe."

In a further communication Dr. Taggart states:[1]

"**Wax and its Treatment.**—To be scientifically correct, a wax must be of such a nature as to be sluggish in movement, and which, at the temperature of the mouth, will absolutely break before it will bend. Without this quality there is no certainty that it has not become distorted, especially in complicated cavities.

[1] Items of Interest, July, 1911.

"With soft waxes and the use of cold water it is possible to obtain fairly good results in ordinary cavities, but where there are any complications, such as are found in M. O. D. (mesial-occlusal-distal) cavities, the wax, as soon as the cold water is withdrawn, almost immediately resumes the temperature of the mouth, and while it may be easily withdrawn from the cavity, there is no telling to what extent it may have been bent, and this condition will not give a high percentage of successes in the places which should be the most accurately filled.

"I have made eleven hundred and fifty different mixtures of waxes and gums and did not succeed in having continuously successful results until a wax was obtained which possessed the foregoing properties, but others seemed to think it required too much effort to get it to a workable condition. From the start it was found that the uniform plasticity throughout the whole mass could best be obtained by warming in hot water, but in trying to do this in a hurry the surface was made softer than the internal mass; yet if sufficient time were used to allow the whole mass to be thoroughly heated throughout, excellent results were obtained. To surmount the problem of heating the wax properly, I have devised an automatic electric heater (Fig. 404). When the instrument is set to work so as to give the proper degree of plasticity, it will always duplicate this temperature, but it must be allowed time to arrive at this correct temperature, and by making it automatic this can be accomplished to a nicety. As soon as I commence to prepare the cavity, the heater is started, and this gives ample time for the wax to be thoroughly warmed throughout its mass, so that when the cavity is finished the wax is ready to be used, without loss of time, with annoying conditions removed, and with continuously duplicated and gratifying results. This instrument has brought the moulding of the wax pattern down to practically a scientific basis.

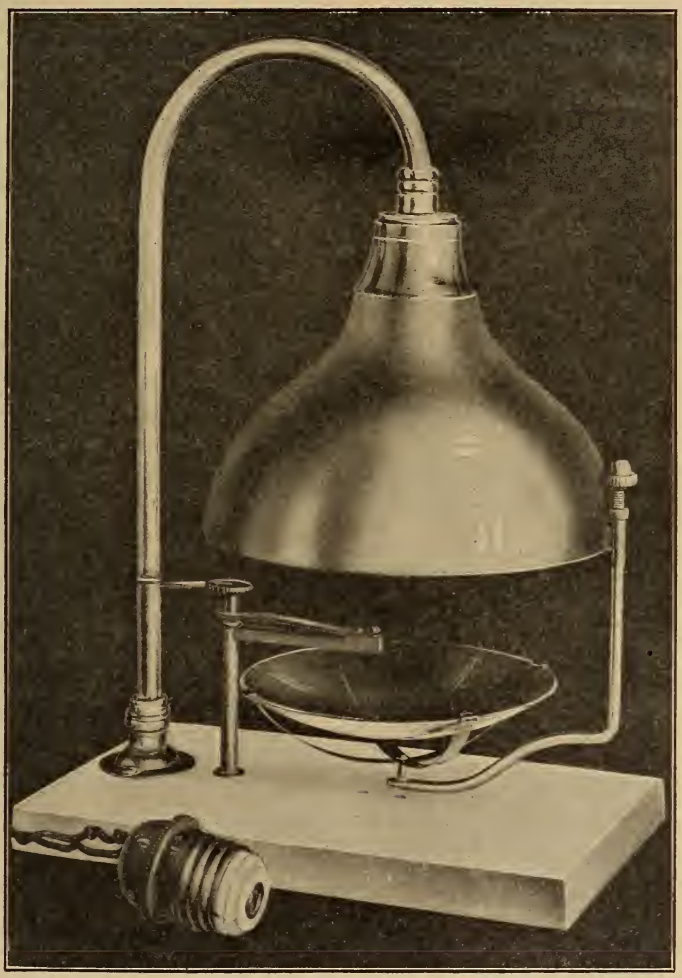
"This instrument (Fig. 404) has as a heating element a 16-candle-power lamp, with a carbon filament. The carbon filament is being abandoned for lighting purposes, because it furnishes more heat than light. The Tungsten filament furnishes more light than it does heat. For that reason I have used the carbon filament to furnish the heat.

"It works on the following principle: There is a glass disk, which can be turned to one side in order to place the wax on it. As all the heat comes from one direction, a flat metal disk or surface would receive heat upon its upper surface, and the under surface of the wax would be cool. I found that one of these disk glasses is thin enough so that as the heat strikes it, it is reflected back so that the under side of the wax is warmed as well as the upper. I have had wax in the instrument for fifty-six hours at a time, and when I examined it it was plastic in its mass, and no more heated on the upper than on the lower side.

"The electric heating apparatus was hard to control automatically if the current were allowed to go in a continuous path, but by adopting

the principle I have used, of having the heat all on or all off, it permits the intermittent heating of a thermostat. It heats the thermostat, which, as soon as it gets a little too warm, breaks the electric circuit. When the electric circuit is broken the thermostat begins to cool down, and the thermostat throws the current into the lamp again. It works by excessive heat, and it shows there is not a one-hundredth degree of

FIG. 404



difference in temperature between the surface on one side or the other. Sometimes it will flash 50 or 60 times in a minute; sometimes slower. The reason is, it is a very sensitive test of the voltage that is passing through the wire. It has been often noticed that when the lights would go up high it would make the room light enough. When the current is at a high voltage the lamp is heated more, and that works the

thermostat quicker, and as soon as it is worked quicker, it immediately drops down. The movement is caused by that voltage.

"The wax is placed on the glass disk and the even temperature throughout the whole mass has a great deal more to do with the correct moulding of wax in a tooth cavity than appears. It is peculiar, but a soft, wobbly condition of the surface of the wax will invariably make it shrink from the cavity walls; whereas, if the wax is of a uniform texture, it will move to its place in an exact way, and there will be no change in form when it cools off.

"**Investments for Cast Inlays.**—This problem of investments seems to have caused more trouble than even the wax problem did, and justly so, as after the pattern, which must be accurate, the mould must be scientifically correct. A great many of the faulty adaptations, aside from those caused by distorted patterns, come from improper investments, or good investments improperly handled.

"One writer has given several pages of meaningless statistics about investments. I have not been able to fathom their meaning, because, if investments are tested under conditions which should never be allowed, no number of pages of statistics can make me believe that this would be a scientific treatment of the subject. For instance, temperatures of 1000° are mentioned; as a matter of fact, such a temperature is so far beyond the requirements that the article loses weight as a scientific treatise. The temperature required in order to do scientific casting should never be higher than just enough to burn out the wax. Anything beyond this is absolutely harmful and brings the investment to a temperature where the ingredients themselves are burned and give off gases which are very objectionable in a mould.

"The temperature in the flask at which casting should be done has not been thoroughly understood. A hot flask is an expanded flask, and an expanded flask means an expanded hole inside, and an expanded hole means a misfit casting.

"I think one of the most scientific reasons why I have such continuously satisfactory accuracy in the fits of my cavities lies in the fact that I never cast in a mould hotter than the temperature of the room. In other words, always allow the flask to become cold. This gives two conditions, both important. One is, the mould is not distorted, and the other is, that the metal flask, in being allowed to come back to a normal temperature, hugs the investment tighter and gives it a support which is very helpful in resisting the pressure from within.

"Most of the handling of investments is done in a very unscientific way; as a rule, there are no two times that the conditions are made the same. Experiments in sufficient number should be made to determine the correct quantities of water and powder, and then these proportions should invariably be duplicated; otherwise, how can uniform results be obtained? There must be some proportion of water and powder in any

investment, good or bad, which is the correct one for best results with that particular investment, and when this is determined it should invariably be duplicated. This can only be done by weighing the ingredients and not by measuring, as it is impossible to always get the same quantity of powder in a vessel unless it is weighed. A little pressure or tapping will alter the quantity away beyond reason. From the start I have insisted on exact weighing of both water and powder, and this accounts again for a high percentage of uniform results in my work. A rule of thumb method will never accomplish scientific casting. A little water and a little powder, and if too thick, a little more water; and if this time it is too thin, then a little more powder, will never give two mixtures alike, and if the consistency of mould is not twice alike, the casting results certainly cannot be duplicated.

"A good investment should be so compounded as to make it possible to pour it into the flask, and have plenty of time to know that the wax is thoroughly surrounded. A thin investment also allows the contained air to more easily escape. When I was using a thick investment and manipulating it hurriedly, as was necessary, I would find pimples on the gold far in excess of what I thought was caused by the contained air in the plaster ingredient, and I came to the conclusion that gases must be evolved after the investment was in its place in the flask. By making a proper mixture of ingredients, it now allows me so to manipulate the material that any contained air or gases are allowed to escape before the flask is filled.

"In order easily to weigh and mix investments to get uniform results, I have devised several instruments by means of which this object can be obtained and scientific casting has taken a long step forward.

"**Investment Mixer.**—This apparatus was among my first instruments for mixing investments. It is an open tube, and a movable other end to the lever. In the centre is the fulcrum. There is a movable weight. Imagine the fulcrum at a certain point. On top of it I have a spirit level. Without that it would be impossible to tell with the eye whether this end or that end was too low. If either condition existed correct proportions of water and powder could not be obtained. As soon as the spirit level comes to a centre, that is the correct amount.

"This is a movable weight between two nuts. When it is to the left there is a certain amount of powder, and when to the right there is a certain amount of liquid.

"The spirit level shows the weighing beam is level. I now move the weight over to the right side. That brings it out of balance. By squirting the water in, and bringing it back to balance, we have the correct quantity of water.

"Those two ingredients are in there in the proper proportions, and those conditions can be duplicated every time, and after the proper

proportions have been found, the advantage can be seen. It is liquid enough to shake it and get the ingredients properly mixed.

"The element of time comes in. These gases seem to be evolved from the chemical action of the water on the plaster, hence the liberation of contained air and gases. The plaster taking up the water, whatever gases or contained air there may be in the powder or water, are given a chance to be eliminated by rolling it from one end of the tube to the other, and giving it a slight tap occasionally. As it is rolled in this way the gases come to the surface. They have a great attraction for the water, but a little tap or jar will break them loose, and then the process is repeated and the rotary motion given. Three or four minutes of time can be consumed in this way, and the investment is still in a workable condition.

"When it is ready, the inlay which is on the crucible former is carefully painted over with a small camel's-hair brush, so that there is no air pocket concealed in any angle, and the investment is then poured into the flask. It is in a liquid condition, and is absolutely free from all the gases and bubbles that have formerly caused annoyance, and which invariably produced the little nodules of gold on the surface of a filling. It is easily seen how a thick investment could confine this air, and the air, having some buoyancy, will rise somewhat; but it has not enough buoyancy to come out, especially when it strikes the under side of the inlay. Any jarring of the flask at this time is the worst thing that can be done, because the colonies of small bubbles of air and gases congregate and cling to the under side of the wax pattern. The investment stays thin for ten or eleven minutes, and apparently it is so liquid it never will set; but when it is looked at again after turning aside for a moment and forgetting it, it has set. It turns rapidly from a liquid to a solid. At the end of twenty minutes it is ready, even when mixed in this liquid form, to place on the fire.

"In order to mix these ingredients properly I felt as though the instrument was rather crude, and that a more accurate and automatic instrument should be made (Fig. 405).

"In this vessel I mix the ingredients. There is a spring that allows the rod to be shortened. It was put in a little hole in one side, and one on the other side. In the other device there was a chance to change the length of the lever in the scale beam. In other words, in dropping the powder into it the bulk of it would pile up on one side. That would make the beam longer, and a true measurement would not be obtained. If it were possible always to place it absolutely in the centre it would weigh properly. The liquid takes care of itself. I made a movable joint in this, so when the powder is put in, it tips it over and brings the centre of gravity below the point of support.

"The instrument is handled as follows: I hang it on the fulcrum. The arm has a spirit level in the top, the same as the other. The weight

is pushed to one side, the powder is placed carefully; it must be remembered that a little too much powder or too much water will make it of such a consistency that it will not roll in the container, but will become sluggish and mushy. The weight is now moved to the other side of the scale beam. Water is poured in until it comes to a balance again. The spring is removed and the lid placed on and shaken up so as to get the ingredients mixed. It will be noticed that the arm leading off from it is placed at an angle. This is placed on the motor, and we have a cog motion here which reduces the speed of the container to about sixty

Fig. 405



revolutions a minute. This mechanism is an automatic one. In my work I allow five minutes for the mixing. Five minutes is better than three minutes, because every chance is given the gases to escape in this time, and the five minutes may be occupied with other work. I take the wax inlay after it has been placed on the sprue wire, start the automatic instrument, and then do the artistic carving and finish up the wax filling; and often I have plenty of time to do all the carving that is necessary while this mixing of investment is going on. By setting the clock at five minutes the mechanism revolves. There is a little jerking

motion each time. This jar is to burst the air or gas bubbles. The bell rings and the machine stops automatically. The automatic device for stopping is nothing more than a snap switch placed on the alarm end of the clock, so that the alarm movement is the one that throws off the switch.

"The material is now ready to be poured into the flask. It is of a much better consistency even in the few minutes I have mixed it—freer from air bubbles—than in any other way in which I can mix it. If it is jarred in a more violent manner more air is apt to be pumped into it.

"By allowing the disk to revolve alone the angle at which the container is set is continually changing, which keeps the liquid investment constantly changing its place and spreads it in a thin layer on the inside, and the jar bursts the gas bubble.

Fig. 406



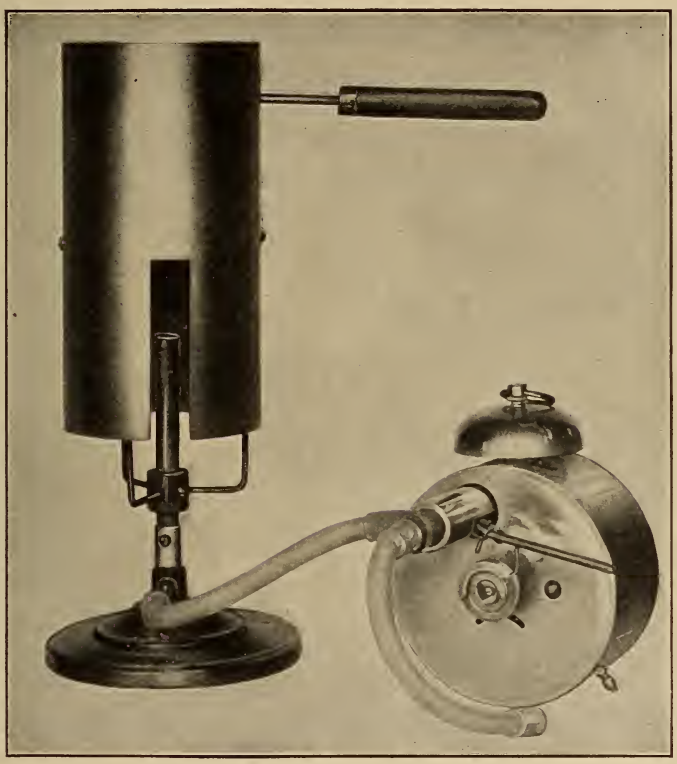
"There is another automatic mixer (Fig. 406) that can be connected with any of the lathe motors. This is a Ritter. This machine works on the same principle as the other. As the mixing goes on for the requisite number of minutes the clock movement goes along, and the jarring motion is obtained. The fact that there is an alarm loud enough to draw attention to the fact that the work is ready, is better than the assistance of anyone in the mixing. It permits the work to be done identically every time.

"**Method of Removing Wax from Mould.**—The case is now flasked. It is seldom that wax has been burned out successfully twice alike. As this process takes considerable time and it is not considered necessary to watch it, there is great likelihood of overheating and spoiling the mould by forgetting it, sometimes leaving it on the flame for hours. If continuously duplicating conditions, as I have previously outlined, is

of any importance in scientific casting, it is equally so in the simple burning of the wax. I have devised a burner for this purpose which does the work automatically and thus becomes a great time saver.

"**Automatic Apparatus for Burning Out the Wax.**—In this instrument (Fig. 407) I have three different degrees of flame. If great care is taken when the first low heat is put on, and plenty of time allowed for the water to be evaporated out of the investment, as much heat as is desired may afterward be put on and as fast as may be wished.

FIG. 407



"This low heat is without signification unless it is confined. The swaying of the flame by draughts would mean continual variations of temperature. I put a tube over as a chimney to make the flame come to the top always and to prevent its swaying.

"On the back part of another alarm clock there is a disk which has three steps and a valve of special construction. This level first rests on the first step, and as it is set for five minutes the clock moves at that low heat, and then drops on to the step next higher. That temperature is kept up for another five minutes, which precludes the possibility of any further moisture which might suddenly burst and destroy the invest-

ment. As time goes on—another five minutes—it drops off, and it goes up another step. That, we will say, is the third and highest temperature. At the end of that time another five minutes elapse, and the switch goes off and the flame goes out.

"**Gold for Casting.**—The next phase of scientific casting concerns the gold itself. If there is any one thing more than another which has hindered the scientific casting of inlays, it has been the eagerness of the dentist to use all of the old refuse gold about the office. The question of saving on an average sized filling, say as large as one and a half pennyweights, would amount to ten cents when pure gold scrap is used. In the case of 22 k scrap, fourteen cents would be saved on the filling, and in 20 k scrap, about sixteen cents. For a filling of this size not less than ten dollars should be obtained, and not more than a hundred. Now let us see how this figures as to cost. If a failure occurs on account of using bad gold on a 22 k scrap filling at ten dollars each, it would require seventy-one and three-sevenths fillings, and on the one hundred dollar filling, seven hundred and fourteen and two-sevenths fillings to come out even on that one failure. Real, ethical, scientific, artistic, humanitarian, and opposed-to-patents dentists cannot afford to prostitute themselves to this extent.

"So much for the commercial side. Now, as to the scientific aspect of knowledge gained and verified by exact observation and correct thinking.

"Dental golds are alloyed with either silver or copper, and in case of solders, zinc is used. It is a well-known fact that silver and copper, or any baser metals, readily absorb gases when melted, and these gases, principally oxygen, form oxids of the metal, and on cooling evolve these gases, which causes the blowholes, or porous cast. The elimination of these absorbed gases also causes the sputtering in alloyed gold, which does not occur when pure gold is used, as the latter in its melted state does not absorb gases; consequently, when cooled from the melted condition, it has no gases to squeeze out, and it is necessarily exceedingly homogeneous.

"While it is known that platinum is non-oxidizable, and might have properties helpful to gold, it must be borne in mind that platinum at these high temperatures has a very great affinity for silicon, and a piece of pure platinum melted in a crucible with but a small portion of silica will become very brittle. This possibly accounts for the brittleness of clasp gold when cast, as clasp gold is supposed to be alloyed with platinum.

"All of these conditions I have found out by practical experience, and have had them verified by expert metallurgists. What do these experiments mean? They mean that if cast inlay fillings are to be made in a truly scientific manner pure gold must be used. There are also a great number more of clinical reasons favoring the use of pure gold.

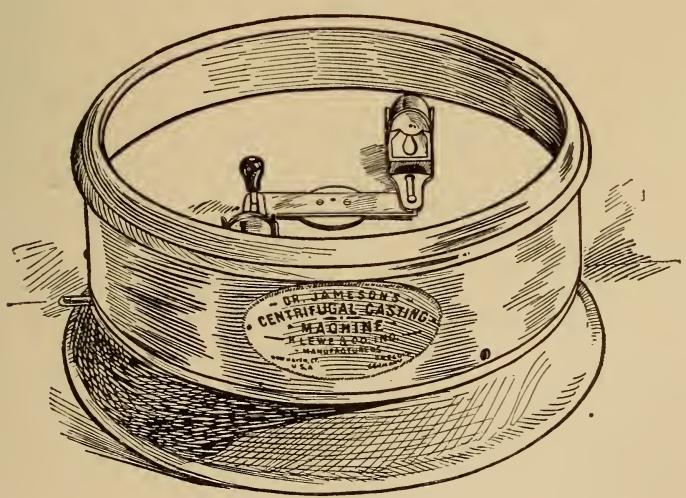
"But what is to be done in cases where more strength is required, as in bridge spans, plates, etc.? Choose the lesser of the two evils and use coin gold, which is alloyed with copper, and if not melted over and over again the gases do not injure its ultimate structure as they do silver, zinc, and platinum.

"**Casting against Pick-ups.**—One more principle about gold should be mentioned, the casting of it to other pieces of gold which are in the flask.

"Without any experience except that gained by blowpipe work, the first thought which seems to come to dentists when they wish to cast against gold is to bring both the golds to as near the same temperature as possible. This process absolutely defeats the object sought.

"In bringing the flask and its contents up to a bright red heat, the enclosed metal is brought to a temperature at which it oxidizes, and as there are no means of deoxidizing this surface, a less perfect union is obtained when the melted gold is thrown in than when the case is heated up to a temperature just sufficient to burn out the wax. This temperature does not absolutely burn all the carbon off the enclosed gold, and as carbon is one of the very best deoxidizers, the gold is now in the very best condition to be welded to other gold. The proper scientific method in order to cast to this gold is to bring the melted metal up to an excessive temperature.

Fig. 408

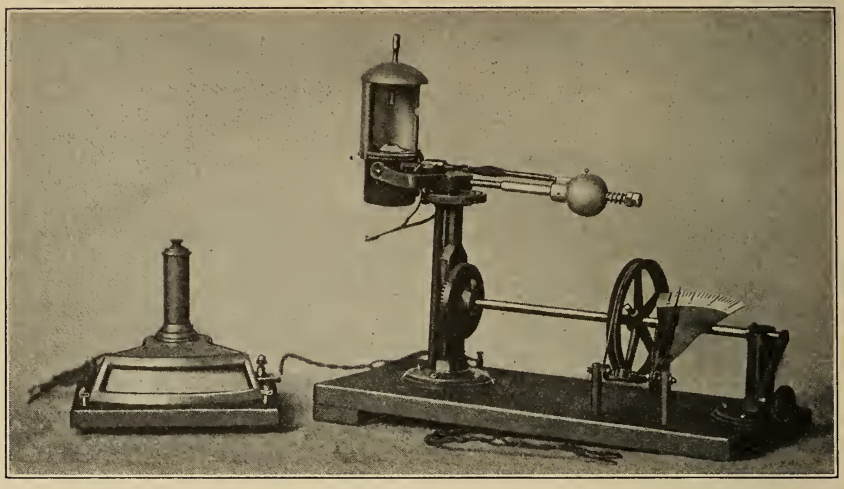


Jameson's casting machine.

"**Pressure.**—The pressure used is an important factor in scientific casting. It may be too low to do accurate casting, or, on the other hand, too high. The intermediate pressure which is just right can only be obtained by automatic controlling mechanism."

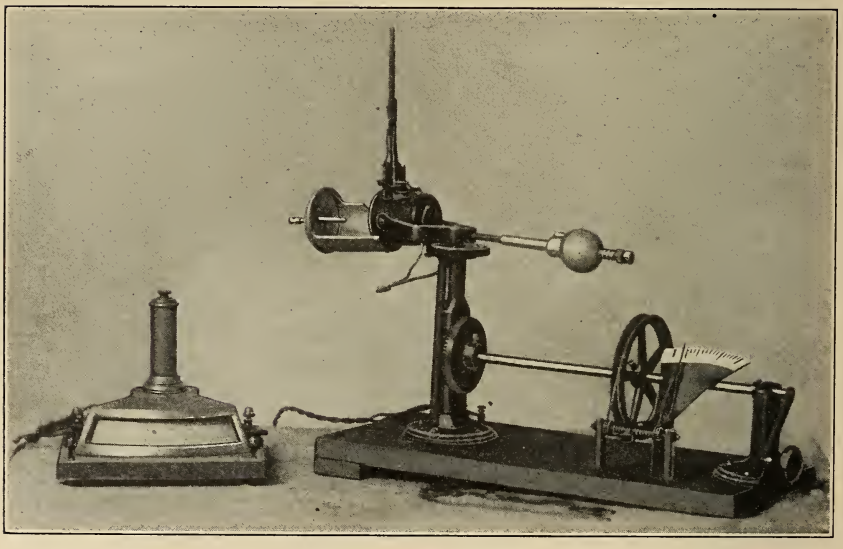
The introduction of the Taggart machine was quickly followed by many others, some of them notably ingenious. That by Dr. Custer is

Fig. 409



Price's casting machine.

Fig. 410



Price's casting machine.

distinctly different from all others because of the fact that the gold is melted by electricity. This machine has been withdrawn from the market, but was a favorite for some time.

Jameson's is again different because the gold is thrown into the mould by centrifugal force (Fig. 408). This machine is circular in form, with extended arms, on one of which is the mould and crucible for melting gold. These are set in motion by releasing a strong spring, forcing the arms to revolve at a rapid rate, which throws the gold into the mould. This apparatus is very efficient. There are several others of the same principle used on lathes and home-made contrivances, which cast by holding in the hand and swinging in the air. Dr. Weston A. Price has devised a most interesting and effective electric casting machine, entirely different in design from all others of that kind, and as it is deserving of more than passing notice, Dr. Price's description is given:

"The centrifugal casting machine shown in Figs. 409 and 410 was designed both for experimental and practical work, and is particularly satisfactory and efficient for both.

"The gold is melted to the desired temperature in a crucible in a resistance muffle like the muffle of a porcelain furnace. The temperature of the gold is indicated by the pyrometer. The muffle and its contained crucible are in the vertical position until the instrument is started revolving. The cup carrying the investment to be cast into is inverted over the crucible.

"Since the rate of the revolution is a constant factor in determining the actual pressure, together with the weight of the column of fluid, and the radius of the circle, an indicating needle is geared to the driving shaft, and indicates the pressure being exerted by the fluid gold.

"When ready to cast, the head carrying the muffle, crucible, and investment is revolved by the hand lever, and the heat remains on until it automatically releases itself by a counterweight condensing a spring and opening a latch. The gold thus enters the investment at high pressure and at the full heat. Twenty per cent. platinum in gold can readily be melted in it.

"Large cups are used for large cases like plates and bridges.

"It is particularly valuable for casting into hard models, like the artificial stone which can withstand a very high pressure without distortion."

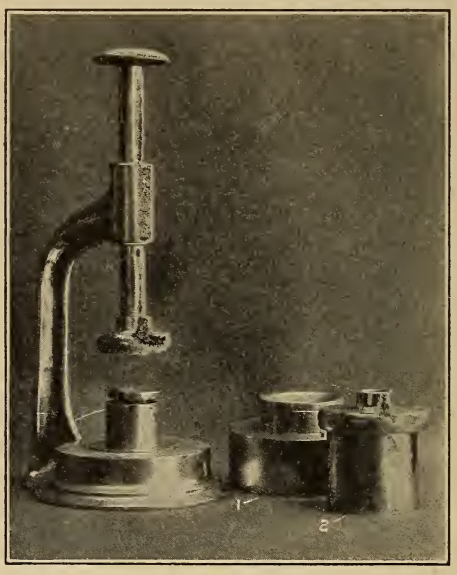
The most popular machines, because of their cheapness and simplicity, are those of the press or stamping form, and the Seymour is representative of that class (Fig. 411).

The metal is forced into the mould by wet asbestos packing pressed over the flask rim. This contact with the heat produces steam, which forces the molten metal into the mould. Bridges and full dentures are successfully cast with these appliances.

Successful casting does not always depend upon the machine employed, as due consideration must be given to the technique and the quality of materials used such as wax and investment. These articles are as

varied as the machines and their merit depends largely on the manipulator, although it is now generally conceded that an investment composed of three parts of powdered silex to one of best impression plaster will give the best results under all circumstances.

Fig. 411



Seymour's casting machine.

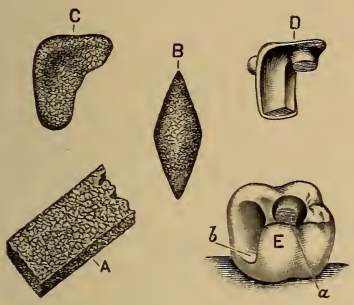
ALEXANDER'S METHOD OF MAKING GOLD INLAYS

This is a simple and rapid way of making gold inlays, and with a little experience, accurate results can be obtained. A plastic mouldable gold is made especially for this purpose, and is used in the following manner: Tear from the plastic gold matt a piece of gold of sufficient size and compress into a double-headed cone, using the greatest force possible with the fingers, then introduce it to the cavity prepared as in Fig. 412. These cavities in bicuspids and molars are prepared with a retention pit, differing from other cavities formed for inlay work. The cavity and gold are kept dry until the gold is packed with instrument pressure, using various sizes of burnishers for this purpose. The gold being very plastic it can be handled similar to a wax impression, noting the occlusion and finishing the surface in the same manner.

If the gold pellet is deficient in size it can be added to providing the surfaces are dry when the form is complete; it is then removed from the cavity and invested. The investment is made to form a slight crater-shaped gateway through which the gold solder enters when placed and fused upon this surface (Fig. 413); 20 or 22 k solder should be used

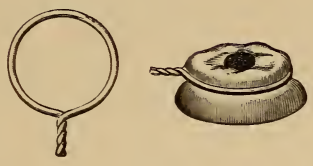
for solidifying, cut into small squares and mixed with freshly ground crystal borax.

FIG. 412



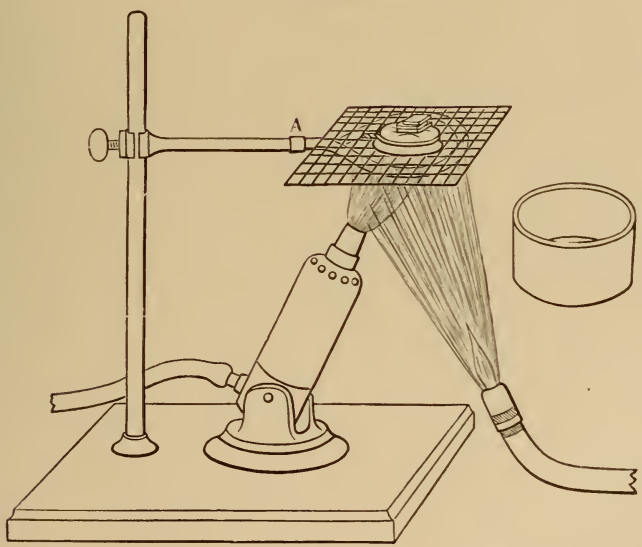
A, plastic gold for making inlays; *B*, portion of plastic gold moulded into a double cone; *C*, the same teased into approximately the shape of the cavity; *D*, fused inlay, showing excess of gold in button at the left; *E*, cavity prepared with flat seats, *a* and *b*, to support the inlay.

FIG. 413



Soft iron loop, as made and as embedded in position on the investment, in the crater of which is seen the plastic gold ready to receive the solder.

FIG. 414



Soldering apparatus: Adjustable gas-burner, soldering frame and support, with investment in position, with the flame properly applied. The ring for confining the flame is placed on the wire frame around the investment and another wire frame on top of the ring.

The piece is slowly heated over a Bunsen burner (Fig. 414), then with a broad brush flame from the blowpipe, causing the solder to fuse and be absorbed by the gold within the investment. Before seating the inlay, it should be finished with a corundum wheel, being careful to trim away all overlaps along margins.

No time whatever is lost in making inlays by this method, as the heat is applied while the investment is green. The paper upon which it is made is burnt up in the process of solidification. Sump is used for the investment, as it does not disintegrate from immediate application of heat.

MAKING INLAYS BY THE SWAGING PROCESS

While the majority of porcelain workers are satisfied that the best results are to be obtained by working directly on the tooth from start to finish, it is claimed by others that results equally as good may be had by swaging, or by what was originally known as the water-bag process, introduced a few years ago by a London manufacturing firm.

The system has some ardent supporters who claim that by it the presence of the patient is needed only for the impression and the finish of the inlay, the rest of the operation being done in the patient's absence and by a laboratory assistant if so desired. The claim is plausible, and from the fact that many dentists use this process, makes it worthy of consideration.

Dr. T. T. Van Woert is an ardent supporter of this form of operating, and in a recent article on this subject says: "The essentials necessary for securing an accurate impression of any cavity are (1) suitable trays; (2) proper impression material, and (3) a knowledge of its manipulation.

"The material for trays which have given me the most satisfaction is sheet platinoid of 32, 34, and 36 gauge, because it has a rigidity, together with more pliability than any other metal than I have been able to find. Another very good quality, while not essential, is that it has a finely finished surface, which at least has the appearance of being clean, and is pleasing to the patient. The second requisite is the impression material, and while it is a matter of opinion, personally, I prefer that made by the Detroit Dental Mfg. Co., because it softens at a lower temperature, sets quicker, and when cold is as hard if not harder, and gives a very much sharper definition of detail than others I have tried. After forming the tray, a suitable quantity of compound heated, the tray held over the flame until it is hot enough for the material to adhere to it, and the compound then pressed into a cone-shaped mass with the fingers and then chilled. The surface of the cone should be held in a small flame, so that it is quickly heated to the point of running, and then forced into position, and either compressed air or cold water used for setting it.

"I find it a great advantage in large cavities in molars and bicuspids to force between the tray and adjoining tooth the blade of a thin cement spatula to bring up a sharp line at the cervix. This is easily removed after the chilling, and facilitates the removal of the impression as well. This is frequently advantageous in approximal cavities of the anterior teeth also.

"Method of Making Amalgam Models.—If we have succeeded in securing an accurate impression, it is only the beginning of a successful ultimate result, and the next procedure, that of making the model, requires as careful consideration and manipulation as any part of the technique. Various materials have been recommended for this purpose, all of which I have given a most careful and impartial trial, and I am forced to the conclusion that there is but one reliable material, and that is a good amalgam. When I say 'a good amalgam,' I mean one having good edge strength, as little shrinkage as possible, and the property of setting quickly, although this is not essential. I use the standard alloy made after one of Dr. Black's formulæ.

"First the impression must be embedded in plaster to a sufficient depth, and with enough body surrounding it to permit of pressing the amalgam well down into the impression. The amalgam is then mixed with enough mercury to make it very plastic, and this is burnished into place with suitable instruments until the impression is filled. Then the excess of mercury can be eliminated by folding a piece of rubber dam several times, and placing it on the amalgam and pressing upon it with the thumb.

"The mixing of the amalgam is one of the most important points in the procedure. In my early efforts I tried to fill these impressions as I would a cavity in a tooth, and the force required in burnishing it to place invariably marred the impression which resulted in an imperfect model of the cavity.

"Advantages of Impression Method.—If we succeed in getting an accurate model, a filling made to fit it must fit the cavity which it represents. This being the case, let us consider the advantages to be derived from the impression method: First, we are none of us so perfect in any branch of our art that we are not liable to make mistakes. Second, it is beyond question that we all have many accidents that are just as deplorable as the mistakes we might make, and when such happens in the direct method of making inlays, we are obliged to acquaint our patients with the fact that we have erred, or met with a misfortune in the form of an accident, either of which is humiliating to the operator and frequently exasperating to the patient, and, occasionally, to such an extent that the patient loses confidence and seeks service elsewhere.

"We will take, for example, porcelain restorations. In the direct method, where the matrix is burnished to the cavity, which, by the way, is a much more tedious operation than that of taking an impression, we have confronting us the possibility of some distortion in its removal, or, perhaps, in the handling after it has been successfully removed, as well as the possibility of warping in the fusing of the porcelain itself. There is still further the difficulty which arises in many cases of securing a suitable color, or just the proper form of contour, all of which is a large combination of defects which remains to be explained to the patient.

"The impression method eliminates all of these difficulties. In the first place, the matrix is secured by swedging the gold into the die with the Brewster press, and the swedged matrix is less likely to change its shape when removed than the burnished one. The shape of the swedged matrix can be retained by filling it with a hard wax; it is then removed and invested, and later the wax washed out. Should the filling prove a failure, another, or several others, if necessary, can be made without the patient's knowledge; and where the question of color or contour is liable to cause trouble, several fillings, varying from a light to a dark shade, can be made; or if it be a troublesome contour, several of different shapes, so that when the patient presents, the suitable filling can be selected without subjecting him to another or several operations, and without the unnecessary loss of time to the operator.

"**Cast-gold Fillings.**—The same procedure is applicable with cast-gold inlays, with the exception that the wax filling is fitted to the tooth, as described by Dr. Taggart, omitting the final carving of detail in bite and contour which should be done to the die. If the die is correct, the wax filling will go to place without difficulty; but one is surprised to note the little defects in the filling, such as here and there a small point where the wax has not conformed to the sharp edge of the cavity margin. This is due to the lack of resistance at such places; the wax being of one temperature throughout its entire body, it is forced by the occlusion from inward out, and on a line with the cavity margin. It may be said that this defect can be remedied by running a hot spatula around the line, but I have found this extremely difficult, particularly at the cervix. It is also claimed that such defects may be corrected by burnishing the gold casting after it has been cemented to place. This has proved just as difficult and unreliable in my hands; and it is a potent point that these difficulties do not exist when cast fillings are made from the impression and amalgam model properly constructed."

THE BREWSTER PRESS AND MATERIALS

The cavity is prepared as described for the usual method, edges square, margins strong, and without undercut. Talcum powder is rubbed into the cavity and adjacent surfaces.

Then an impression is taken in cement. This is invested in plaster of Paris, and the surplus cement which extended around the tooth on both sides of the cavity is trimmed away to about one-sixteenth of an inch from the margins. Additional cement is then mixed to a very stiff consistency, the fingers being dipped in talcum powder and the cement well kneaded. The first impression is surfaced with talcum, and this second mix pressed into the first one and allowed to stand until quite hard. Then separate and invest this second impression or model in one

of the steel cups, in plaster, or, if preferred, in one of the very shallow cups, in cement or sealing wax. Invest so that the centre is slightly higher than the edges of the cup. When the plaster is hard, place a square piece of platinum (one one-thousandth of an inch thick) on the cement model. With pledgets of cotton wool press the platinum down into the cavity; put into the swager, with a water bag over the wool, and

Fig. 415

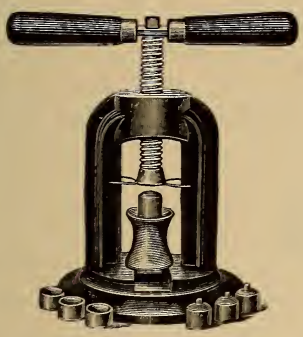


Fig. 416

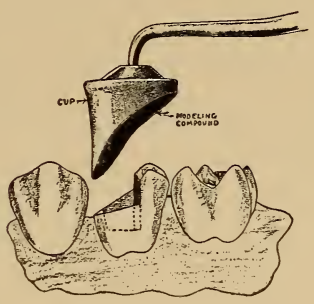


Fig. 417

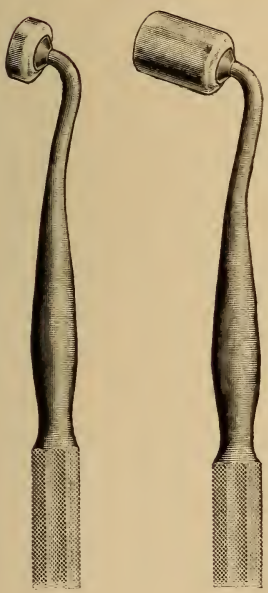
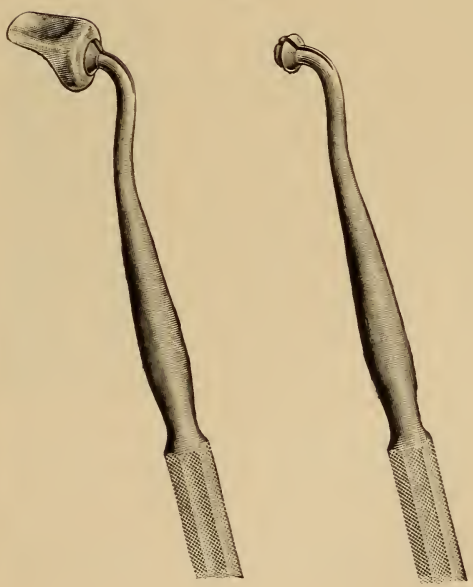


Fig. 418

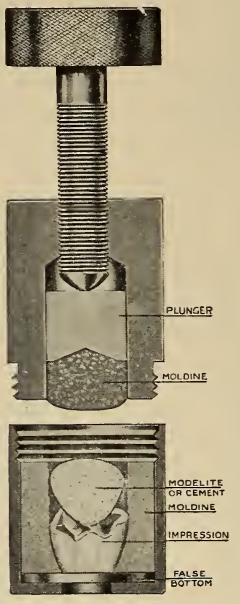


swage. Remove from the swager and burnish out wrinkles or folds; then anneal well in the furnace, replace on the model and re-swage with water bag, but without the wool. Reverse the press handles, remove the cup from the cylinder, and examine the matrix. If any wrinkles or folds still remain on the margins, they must be burnished out; and if the matrix does not appear to be perfectly adapted to all parts of the cavity, it should

be again annealed and then subjected to harder pressure in the swager. Any crack in the matrix at the bottom or near the bottom of the cavity will not affect the fit of an inlay.

In building in the porcelain where the cavity is a large one, first grind an "inlay rod" to fit tightly across the matrix at its widest part; surround this, except upon its upper surface, with foundation body; and when it is quite dry, bake. Keep the foundation body sufficiently away from margins to allow for the thickness of enamel body necessary to produce the desired color. When baked, return to the model, and if in baking the foundation body has caused any change in the fit of the matrix, the next swaging will correct it. After this last swaging proceed to fill in the enamel body. Lay the dark shades in first and bake; then add the lighter

FIG. 419



colors necessary to finish. The foundation body first baked in the matrix will prevent any change of form during the baking of the enamel body.

The press should be screwed to the bench. The solid rubber is for swaging heavy metal cusps and also for inlays. Should a water bag break, carefully dry out the cylinder and plunger. Do not allow any rust to accumulate in the cylinder. The inlay rods above mentioned are made of high fusing material and are of assistance in large contour work by other methods.

The most recent appliance for this process is the Roach model press with trays which are cut to form of cavity and are recommended for bicuspids and molars.

CHAPTER XIV

THE TREATMENT AND FILLING OF ROOT CANALS.

By OTTO E. INGLIS, D.D.S.

The treatment of root canals necessarily depends upon the pathological condition encountered. This may consist simply in the necessity for removal of a perfectly healthy pulp for mechanical or prophylactic reasons, or it may involve the treatment of profound disease, such as apical or even more complicated abscess. Each case therefore must be considered by itself, yet for the purpose of this chapter, root canal cases may be divided into three classes: (1) Those in which the pulp is entirely or in part vital; (2) those in which the pulp is dead; (3) mixed cases. Cases of each class may be either septic or non-septic.

CASES IN WHICH THE PULP IS VITAL

These cases will be considered under the following separate subheadings:

A. **Cases of Healthy Pulps Covered by a Sufficient Layer of Dentin.**—Not infrequently the removal of a healthy pulp is demanded for the purpose of permitting better anchorage of fillings or inlays by means of pins, screws, etc. The use of dowelled crowns, the fixation of a bridge at one or more piers by means of devices involving the use of pins anchored in root canals, or the growing practice of previously devitalizing and treating the canals of such teeth as are to receive hollow metal crowns as bridge anchorages, demands pulp removal. Such pulp removal followed by proper canal treatment is not only warrantable, but advisable in many cases as against other methods of procedure, each case to be considered upon its merits.

B. **Cases of Pulps Covered by Sufficient Dentin, but Exhibiting Evidences of Irritability.**—In some cases the recession of the gum may cause an irreducible hypersensitivity of the dentin which may have been produced by the action of scalers or by the contact of food masses with the necks of teeth, or caries may have resulted of such extensive character as to keep the pulp in such a state of irritability as to permit constant reactions to cold or sometimes hot substances taken into the mouth.

Not infrequently the pain associated with the excavation of such cavities, together with the possibility that thermal shocks will continue after filling, indicate the removal of such pulps. Deeper cavities of decay sometimes permit the impress of temperature changes or the irritation of sweet, salt, or acid substances which cause profound arterial hyperemia of the pulp, with its loss of tone in the bloodvessels, followed by their expansion by the pressure of the blood in them. In such cases venous hyperemia of the pulp may ensue.

The condition of determination of blood to a pulp or arterial hyperemia also occurs in consequence of the presence of large metallic fillings near a pulp; deep erosions or abrasions; metallic crowns on teeth containing vital pulps; leaking fillings producing a septic irritation of the fibrils, but a non-septic irritation of the pulp body; fractures exposing the dentin; pyorrhea upon sound or filled teeth; also infected socket or aphthous ulcer; near proximity of an abscess upon another tooth; blows and reflex irritations from other teeth.

Some of these conditions require removal of the pulp. The reflex cases due to contiguous inflamed areas, the excess of blood in them overflowing into an otherwise healthy pulp, require, as a rule, attention to the causal condition rather than to the symptoms.

When venous hyperemia follows arterial hyperemia, it is due to compression of the vein at the apex, preventing a return of blood to the heart. The vessels expand greatly, diapedesis of red corpuscles may occur, and the pulp usually dies, so the prognosis is bad.

The necessity for devitalization depends upon the mechanical procedures to be carried out and also upon the response to sedative and protective therapeutics, if a preliminary trial of the same has been considered advisable.

Arterial hyperemia which has followed the introduction of a metal filling, and especially of a large gold filling or inlay, and which becomes increasingly profound, so that slight thermal changes cause the patient great discomfort, indicates, as a rule, the devitalization of the pulp, it being assumed that sedative therapeutics are inapplicable or liable to be ineffective. The same is true of vital teeth carrying metal crowns.

Secondary dentin and pulp nodules are in themselves associated with degeneration of the dental pulp, but may lead to further degeneration, so that reflex disturbances may be produced. Reactions to thermal shock may or may not be in evidence, though they usually are.

If discomfort be produced by this the pulp should be removed.

Idiopathic hyperemia sometimes appears in a single tooth. The cause being difficult, if not impossible, of determination without pulp extirpation, this should be done.

C. **Cases of Pulps Recently Exposed.**—The removal of a last layer of decalcified dentin, or sometimes of disintegrated dentin, or careless excavating, may cause the exposure of a pulp. Unless capping be

for some reason indicated, the extirpation of the pulp is indicated. When decalcified dentin in some mass has been removed from over the apparently healthy pulp horn, the pulp itself may for practical purposes be regarded as aseptic and possibly hyperemic, while if exposed by decay or covered by boggy, infected dentin it may be regarded as superficially infected and inflamed. In no case can the character of the infection be determined without microscopic examination, unless pus be actually present, when, of course, pyogenic organisms must be in the pulp. In either case an antiseptic sedative, such as phenol camphor or eugenol, should be placed against it for a short time. Whether the extirpation shall be under cocain anesthesia or after the use of arsenic depends upon the circumstances. As a rule, pressure anesthesia with cocain is a safe method.

In the forgoing classes of cases cocain pressure anesthesia is usually the most prompt method of preparing the pulp for removal.

While an exposed pulp should, as a rule, be removed, two conditions may be excepted: First, when the exposure has occurred during excavation of leathery decalcified dentin in fully formed teeth and the pulp seems uninfected and without marked hyperemic reaction. Even here it is better to confine conservation to anterior teeth in patients of good physical condition for the sake of maintaining the translucency of the teeth. The second condition exists when a root is, in all probability, not fully developed or very much resorbed, and the pulp should be conserved in order to permit it to perform its share in the development or resorption of the root. Even though it be exposed by caries and be infected or irritated, the chance of saving it for this purpose should be taken. The open character of the root end and the size of the pulp favors the distribution of any hyperemia which may exist or arise. In any case the pulp is expected to cover itself with secondary dentin or to lie quiescent against the capping material, and either result may accrue, as subsequent uncovering of pulps comfortably capped for several years has shown.

These advantages have several offsetting disadvantageous possibilities which render capping ordinarily inadvisable except for the object stated above. These are:

1. Possible death of the pulp through hyperemia due to thermal changes.
2. An overproduction of secondary dentin,. the production of pulp nodules, or other degenerative changes, the pulp becoming exhausted and death ensuing. Increased difficulty of subsequent canal treatment may result.
3. Disease of the pulp due to infection beneath the capping material.
4. The time required for assurance of success or failure.

From the foregoing it will be seen that a pulp capping should be a non-conductor of thermal changes and antiseptic or even germicidal in

character; it should also be rigid, sedative, and applicable without pressure, of which a pulp is intolerant, as it is a mechanical cause of pulp irritation. These needs are all met by the use of a sedative antiseptic cement. A mixture of zinc oxid and thymol made while the latter is melted makes a capping fulfilling these conditions. A small piece of the solid mixture is melted and a portion carried on a burnisher or within a metal cap to the pulp. A crystal of thymol placed on this will hasten the setting of the mass. Another good example is Jodo-Formagen, which contains phenol, eugenol, and formaldehyd, together with iodin salts. While the exact formula is not published, its value is amply proved. It may be applied either with or without a metal cap. It is preferable, as a rule, to use a bit of paper to carry the paste to place, later removing the paper, or to flow it gently over an exposure and adjacent dentin by means of a ball burnisher. It soon sets, and when rigid fulfils the object of a metal cap, namely, a protector against the pressure of material subsequently introduced. As a rule, it is better to cover it with zinc phosfate to which about 5 per cent. of powdered thymol has been added.

The manner of using the cement depends upon the amount of retention and the character of the metal filling. When amalgam is to be used there is often advantage in making a combination filling in which soft cement is placed in the cavity and amalgam pushed into it in such a way as to distribute the cement about the cavity and retentions as a thin lining adhering both to the walls and to the amalgam. Under conditions which allow of a large mass of cement, this may be made quite stiff and be gently packed into the cavity, approximately shaped, and, when set, finally shaped to form a supporting intermediate or base for the filling.

Other capping cements of less value are oxysulfate of zinc, plaster of Paris, and oxychlorid of zinc. The first consists of a mixture of uncalcined zinc oxid and a saturated solution of zinc sulfate in distilled water. The plaster of Paris should be mixed with a 1 per cent. aqueous solution of formaldehyd. The oxychlorid consists of calcined zinc oxid for the powder and a solution of zinc chlorid for the liquid. The liquid should be modified by the addition of distilled water in the proportion of two parts of the liquid to one of water. A trifle of iodoform or hydronaphthol may be added to any of these cements.

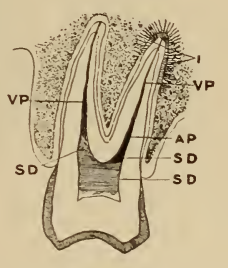
When a lesser condition than exposure exists, or, in other words, a condition of almost exposure, the condition of the pulp should be considered, and if there has not been too much irritation, the pulpal wall may be covered with Jodo-Formagen or thymol and zinc and the balance of the cavity be filled with a temporary cement filling. The subsequent comfort or irritability of the pulp will decide as to whether to fill the tooth or devitalize the pulp. In all other cavity conditions there can be no question as to the advisability of pulp conservation

provided there be no symptoms of unusual pathological disturbance of the pulp.

There may be slight or pronounced hyperemia of the pulp following a capping operation which may be treated by means of counterirritants applied to the gum every other day. If successful, the irritability of the pulp will gradually subside and the tooth will bear hotter and colder applications until a comparatively normal tolerance is reached. Jack has formulated the plan of testing the sound lower incisors while under a rubber dam with hot and cold water of known temperatures until pain is produced, this being regarded as the normal limit of thermal tolerance. He has shown that individual reactions differ, pain being produced at from 74° to 32° F. on the cold side, and at from 118° to 152° F. on the heat side. The data gained by this test may justly be termed the thermal index of the patient, and is a guide in judging the cure of the hyperemia. Of course, if a failure results, the hyperemia will become severe, and there will be increasing response to thermal shock.

D. **Cases of Vital but Septic Pulps.**—Vital pulps may be infected from one of three possible directions. First and most frequently by way of the orifice of the pulp horn or orifice of exposure in case of a cervical cavity. The infecting organisms may traverse either decalcified or disintegrated dentin overlying the pulp, but quite a considerable number of cases have been observed to have followed the dentinal tubules beneath a filling or to have penetrated spaces existing in secondary dentin. The layer of dentin penetrated may be nearly one-quarter of an inch in thickness. Without question the organisms have caused decomposition of the fibrils in their passage to the pulp. In such cases as this partial suppuration of the pulp may ensue (more rarely partial gangrene), and the pus is confined by the dentinal wall. The pathology is that of abscess when the dentin so confines the pus (Fig. 420). The removal of boggy dentin from over a pulp horn may allow a droplet of pus to escape, and in more rare cases a copious flow of pus occurs. Sometimes the abscess is confined within the body of the pulp, which has a white or yellowish-white appearance, the pus only escaping after puncture (Fig. 422). When the pus is confined, either by dentin or the body of the pulp itself, the symptoms are the same, namely, a delayed but intense reaction to heat, due to expansion of the gases against the pulp, with relief from cold applications due to the contraction of the gases. The reaction to cold is sometimes present in the milder forms,

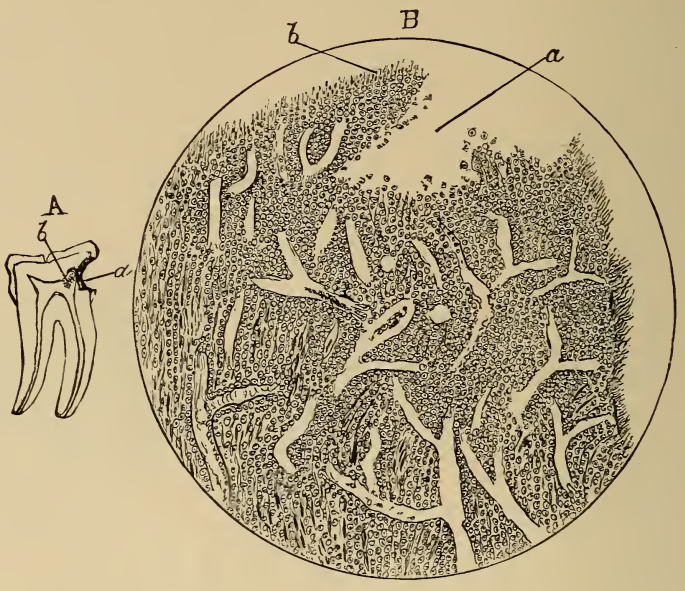
FIG. 420



Abscess of the pulp after formation of a large amount of secondary dentin, dividing the pulp into two portions: *SD*, secondary dentin; *VP*, vital pulp; *AP*, abscess or confined pus; *I*, area of apical inflammation. (Diagrammatic.) (After a case in the mouth.)

especially when a deep cavity is present. The peculiar sporadic cessation and reappearance of the pain when the pulp is not subjected to thermal changes is also characteristic. The pathology of abscess (a circumscribed cavity containing pus) is applicable to such cases as these, and a diagnosis of such condition from the above symptoms is warrantable. When the infection has destroyed a portion of the pulp by suppuration, or other putrefactive process, but the egress of the pus, etc., is effected, owing to an open pulp cavity, the pyogenic erosion of the pulp may proceed until even only a minute portion of pulp may remain vital but evidently infected. This is known as ulceration of the pulp, because it

FIG. 421



A, diagram of lower molar with caries at *a* which exposes the pulp; the darkened portion at *b* shows the extent of the inflammation; the rest of the organ was free from inflammatory change; *B*, illustration of the inflamed tissue, showing a part destroyed by suppuration at *a;* the odontoblasts are undermined at *b;* the bloodvessels which were filled with blood clot in the section are left blank here, that they may be more apparent. (Black.)

consists of an inflamed and open breach in the continuity of the pulp. The symptoms are not, as a rule, severe, consisting of gnawing local pain or possibly of reflex pain in other parts (Fig. 421).

When food is packed into the cavity the pus and gases become confined and the symptoms of abscess of the pulp may appear.

The writer has often found such pulp remnants under faulty canal fillings, in one case after the roots of a molar had been partially filled for twelve years. In some cases partial gangrene of the pulp has been found, due sometimes to neglected cases of arsenical application, at others to the production of venous hyperemia with death of the pulp

bulb only, and in still others the pulp in one or more roots of a molar has remained vital while the pulp in another root has undergone complete moist gangrene.

FIG. 422



Acute suppurative pulpitis in the coronal portion: *I*, intensely inflamed horn; *A*, abscess; *V*, bloodvessels engorged with blood; *S*, superficially inflamed horn; *N*, nest of inflammation. × 10. (Bödecker.)

The second avenue of infection of a pulp is by way of the apical tissue. An apical abscess on a root of an adjoining tooth may by extension of its pus cause apical infection of the pulp of another tooth. This will cause prompt death of the pulp of a single-rooted tooth, but may only cause inflammation of the pulp of a multirooted tooth.

The most frequent cause of apical infection of pulp is, however, found in cases of deep pyorrhea pockets. The infection having reached the apex causes such an infection, which travels downward into the pulp of the denuded root. This pulp filament may be dead or partly vital, while the filaments in other roots remain vital and inflamed.

The third direction, or infection by way of the blood stream, is a possibility, but the condition is only inferential when the case is one associated with some general or profound local infection.

E. **Hyperplasia of the Pulp.**—The exposure of the pulp leads sometimes to a chronic constructive inflammation of its tissue. The pulp extrudes into the cavity of decay, often filling it. Such a pulp may be suppurating upon its surface, and at times it seems to have removed the decay from about it as though the walls had been subjected to a resorptive action.

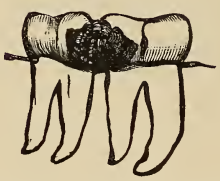
The clinical appearance varies considerably (Figs. 423 to 428).

Fig. 423 Fig. 424 Fig. 425 Fig. 426



Hypertrophy of pulps. (Garretson.)

Fig. 427



Hypertrophy of the gum. (Garretson.)

Fig. 428



Hypertrophy of the pericementum. (Garretson.)

The hyperplastic portion of the pulp may be frozen with ethyl chlorid or saturated with trichloracetic acid and ablated. The balance of the pulp usually succumbs to arsenic. The covering is best made in cases with little cavity retention by driving a fair-sized wheel bur into the side of the concave cavity. A thin, flat piece of spunk is then laid upon the pulp and an amalgam covering built into the cuts made by the bur. Next, the amalgam is cut through and the spunk gently uncovered and removed, leaving a central opening in which arsenic may readily be sealed. The location of the polypoid growth and the condition of the tooth surrounding it, will generally distinguish it from a polypoid gum. If uncertain, it should be pressed away with cotton before applying arsenic.

METHODS OF PULP REMOVAL

There are four general methods by which a patient or pulp may be prepared for the operation of extirpation. These are as follows:

1. Anesthetization of the patient and removal of the pulp during the period of anesthesia.
2. Anesthetization of the pulp by cocain, or in some cases by nervocidin and the removal of the pulp.
3. Anesthetization of the apical tissue and removal of the pulp.
4. Devitalization of the pulp followed by its removal.

1. **General Anesthesia.**—The pulp of a single-rooted tooth may be readily extirpated while the patient is anesthetized by nitrous oxid, nitrous oxid and oxygen, or by somnoform. The instruments should be in readiness, the patient anesthetized, the pulp uncovered by an engine bur, and the pulp extirpated with a barbed broach or Donaldson cleanser.

In cases of multirooted teeth the available anesthetics are ether, which is rarely used for the purpose, and nitrous oxid administered by nasal inhalation. The latter is accomplished by means of a special apparatus having a hood covering the nose, of which the Teter appliance is the most notable example. This is designed to prolong the anesthesia by administering nitrous oxid and oxygen. As it is equally applicable to the otherwise painful excavation of cavities of decay and extractions, it is a valuable means for accomplishing this purpose also.

The ordinary outfit is, however, of value by enabling the operator to remove the diseased bulb of the pulp of a multirooted tooth, after which and while the patient is conscious other methods of removal of the radicular portions of the pulp may be employed.

2. **Anesthesia of the Pulp.**—For this purpose cocain is almost universally employed. There are three practical methods by which it may be introduced into a pulp:

(*a*) By pressure accomplished by means of raw vulcanite. A strong solution (50 per cent. to saturated solution) of cocain hydrochlorid is made in water, or preferably in some mild antiseptic solution which does not cloud on admixture. A small piece of amadou (spunk) is saturated with it and laid upon the orifice of exposure. The cavity is filled with the rubber, and upon this is placed a flat-ended plugger or burnisher broad enough to concentrate the force upon the amadou. A broad piece of amadou placed over the rubber is sometimes of assistance in preventing the slipping about of the rubber. Gentle pressure is now made and a slight pain is usually felt. The pressure should be maintained until this passes away, then it is increased little by little until some force is exerted. The rubber and amadou are then removed, the pulp cavity opened, the progress of the anesthesia tested with a

fine broach, and the pulp lifted away. Some prefer to place a prepared pellet or crystal of cocain upon the pulp.

For multirooted teeth the pressure should be prolonged, and to prevent return of sensation and hemorrhage while extirpating it is well to instil carbolic acid into the pulp tissue by means of a fine, smooth broach.

In some cases the operation fails because the direction of the pressure has been away from rather than toward the pulp or because the spunk has slipped from its place. Sometimes the orifice of exposure may be enlarged, but as sensation is discovered a fresh application must be made.

Sometimes repeated applications fail of effect, though the application is not painful, and at times the pressure is not tolerated at all, owing to the irritability of the pulp. In cases of cavities without walls to confine the rubber, it is well to enclose the buccal and lingual embrasures with the thumb and forefinger. In very broad occlusal cavities the finger tip confines the rubber nicely.

When only canal filaments are present, any septic matter should be removed by syringing repeatedly with an antiseptic solution; then the canals should be thoroughly dried, and the cocain, dissolved in an antiseptic, is carried on a cotton thread into the canals and against the pulp remnant. A small piece of rubber is placed in one canal and the pressure confined to that canal by means of a plugger which will about fill the canal. The action is then repeated in the other canals. This produces better results than a general pressure over all the canals at once.

If used after arsenic has been applied the results are not usually so good, but sometimes the method is successful. To avoid the introduction of arsenic into apical tissue all sloughing portions should be removed.

When the pulp is not exposed, the application to the dentin over the pulp permits advance, a pocket being created in the dentin with a bur, which aids the further instillation of the cocain; finally, the pulp is exposed and the anesthesia is completed.

Clyde Davis recommends for the purpose of producing the exposure the use of a drop of 1 to 1000 adrenalin chlorid followed by a drop of 37 per cent. formaldehyd, then pressure with raw vulcanite.

There is a possibility of the introduction of cocain into the general circulation, and some systemic effect may be noted, though often this will be due to the agitation of the patient. Some patients have complained of tingling in the fingers. If syncope be threatened aromatic spirit of ammonia should be administered, the head lowered, the feet elevated, and smelling salts or amyl nitrite applied to the nostrils.

Hemorrhage following the extirpation of the pulp is sometimes copious. To avoid this, carbolic acid should be instilled into the pulp tissue by means of a smooth broach. A fine Donaldson cleanser may

be passed to the apex of the canal and slowly twisted, the operation consuming several minutes. This torsion of the pulp largely limits the hemorrhage. If it occurs it should be allowed to check itself, although if desired a trifle of a mixture of powdered alum and powdered thymol may be taken upon cotton wet with phenol-camphor and passed to the end of the canal. Deliquesced zinc chloride checks hemorrhag promptly, but its application may be painful.

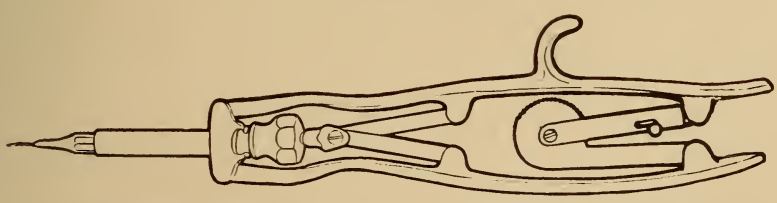
It is an open question whether canals from which living pulps have been removed should be filled immediately or not. There is liable to be a secondary hemorrhage, particularly when adrenalin is used with the cocain. Many prefer to fill at once, claiming that surgical pericementitis is the only result. The writer, as a rule, wraps a twist of cotton upon a Swiss broach, dips it into phenol-camphor, then into formocresol, and applies it to the canal. This, as a rule, permits the healing of the parts without much tenderness, and really consumes but little more time in the aggregate. Moreover, the formocresol tends to mummify the fibrils left in the dentinal tubules.

As an alternate upon the immediate filling side a paste of

℞—Thymol	1 part
Paraform	1 part
Zinc oxid	1 part
Glycerin	1 part

may be used with gutta-percha cones to accomplish the same result. All work should be done under aseptic precautions. Where applicable and not liable to be too painful, the rubber dam should be applied. The writer often uses napkins instead, and relies upon the carbolic acid instilled into the pulp and the formocresol dressing to maintain asepsis. This is repeated if the cavity be douched out.

FIG. 429



The Myers compound syringe for forcing cocain solutions through the dentinal tubules.

(*b*) When considerable dentin overlies the pulp, or when a tooth is sound, the most expeditious method of cocain anesthesia is by means of the compound syringe (Fig. 429). This consists of a strong metal syringe, the piston of which is actuated by means of levers which multiply the power of the hand. The Myers syringe is one of the best, although several forms are obtainable. The syringe nozzle is embedded in a small hole

drilled in the dentin by one of two methods. The hole may be made small with parallel sides, as when drilled with a No. ½ bur. The syringe nozzle has then slightly conical sides at the point intended to jam a fit when introduced with force into the drill pit. In the other method the drill pit is made with a cone-pointed bur or bud bur, and the syringe point is made flat-ended, a form easy to maintain upon the point. A 4 to 10 per cent. cocain solution is sufficient, and all air must be expelled from the syringe. It is wise also to expel all air from the drill pit by a slight pressure while the syringe point is loosely held in the pit. Then a rotary motion under forward pressure embeds the point.

If no leakage occurs the force of the piston drives the cocain through the fibrils in the tubules and into the pulp. The pressure must be maintained for about three minutes. The anesthesia is then tested by drilling with a No. ½ bur in the direction of the pulp. If the dentin be sensitive the syringe is to be reapplied. Often the bur sinks into a sensitive pulp without warning by dentinal sensitivity. In such case the syringe is reapplied for a moment, when, as a rule, the anesthesia will be complete. In all cases when testing, the drill hole should not be enlarged, as this prevents reapplication. Too much cocain should not be introduced, as it has happened that the area about the apical tissue has been profoundly injected, with, of course, possibility of systemic complication. This warning applies to the second application rather than the first. When desirable, the enamel of a sound tooth which is to be crowned may be ground away until the dentin is reached, or if enamel must be removed in only limited degree, as for a tap upon the lingual side of an incisor or in the fissure of a bicuspid, a "spot" is first made with a dentate bur, then a spear drill is driven through the enamel only just reaching the dentin. The drill hole is then enlarged as widely as permissible, after which the pit is made in the dentin with a No. ½ bur.

The lingual side of upper incisors will permit of sufficiently direct pressure to enable the operator to centre the syringe point, but in many cases in which crowns are indicated the labial side may be used with advantage, especially at the neck when the cementum is exposed. Later, the entrance tap is made in line with the pulp axis. The labial or mesiobuccal side must always be used in the lower teeth, unless a cavity be used, sometimes preferably at the neck, sometimes higher up. In cavities having sufficient dentin over the pulp the pit may be made in the pulpal wall, and if for any reason it is needed the drill pit may begin at the cervical portion of the cavity and extend into the root dentin and parallel with the pulp. The pit must be deeper than the syringe point will penetrate, so that the pressure may force the solution laterally through the tubules, which are at a right angle to the axis of the pulp and the pit.

The considerations pertaining to the pulp removal are the same as in the other forms of pulp anesthesia.

(*c*) The third and least desirable form of cocain anesthesia of the pulp consists of its introduction by the cataphoric current. It has the disadvantage of consuming more time, but may serve when patients are timid. A 10 per cent. solution of cocain hydrochlorid is applied to the pulpal wall of the cavity, the tooth being previously placed under rubber dam. The anode of the cataphoric outfit is applied to the cotton and the cathode placed in the hand or at the cheek.

The dentin may be anesthetized as well. If desired, this method may be used to obtain a pulp exposure and the pressure method employed to complete the operation.

When beginning with an exposed pulp, about fifteen minutes will be required unless hyperemia of the pulp exists, when a longer time will be required. As with the pressure method, there may be occasional failures. It will be noted that there is advantage in time and convenience in the pressure methods.

(*d*) The fourth method of producing pressure anesthesia consists in the use of carbolic acid in place of the cocain or in case of obstinate canal filaments of a solution of cocain in carbolic acid.

When pulp nodules or calcific degeneration exists there may be some difficulty in introducing the cocain, but after a first or second application the nodule may be lifted away and further pressure made, although even at this point failure may occur.

In all cases presenting difficulty in introduction, desiccation is a valuable preliminary. Cook[1] recommends an application of 10 per cent. sulfuric acid for a few minutes, followed by sodium bicarbonate previous to a reapplication of the pressure anesthesia as highly effective in aiding penetration of the cocain.

(*e*) The fifth method of producing pulpal anesthesia is by the application of nervocidin, an alkaloid obtained by D. Dalma from the East Indian plant *gasu-basu*. Arkövy recommended that a portion be applied to the exposed pulp for twenty-four hours, when it may be removed painlessly. Söderberg suggests the addition of a small amount of cocain hydrochlorid to overcome the primary irritating effect of the nervocidin. He prefers the following combination:

℞—Gum arabic ʒj
Zinc sulfate ʒss
Water f ʒj—M.

Dissolve the zinc sulfate in the water, add the gum arabic, stir, let stand for twenty-four hours, and strain.

℞—Of above solution f ʒij
Nervocidin gr. x
Cocain hydrochlorid gr. x—M.

To a portion of the latter solution add uncalcined zinc oxid to make a cement which is placed in the floor of the dried cavity. Cover with cement. If dentin be over the pulp, an additional application of twenty-four hours' duration is required to obtain an exposure.

[1] Dental Review, 1905.

3. **Paralyzation of the Transmitting Apparatus.**—The third general principle upon which pulps may be extirpated consists in paralyzing the nerve filament leading from the pulp to the larger branches of the fifth nerve. If the nerve in the apical tissue can be prevented from transmitting sensation, the operator may remove the pulp surgically without pain. The apical tissue is to be located as nearly as possible, the gum sterilized, and an injection of about five drops of a 1 per cent. solution of cocain containing adrenalin injected as near the periosteum of the bone as possible. This is expected to infiltrate the apical tissue *via* the collateral vessels in the bone. To permit the accomplishment of this a little time should be allowed. On drilling the dentin to open the pulp cavity, one should note the presence or absence of sensation, and upon exposure a smooth broach should be used to test the state of the pulp. In the use of this method precaution should be taken to administer an antidote before using the cocain. What is called diploë anesthesia has been employed to relieve the pain of dental operations, and consists of cutting to the bone after the above injection, perforating the bone, and injecting into the diploëic structure. A method employed by some bridge-workers consists in notching and excising sound crowns. It is claimed that for a short period after the excision the pulp is insensitive and can be lifted away with a broach. If for any reason this should fail, other immediate methods can be employed

4. **Devitalization of the Pulp.**—Devitalization of the pulp by the use of arsenic as a preliminary to its successful removal is the oldest of the methods employed at the present day, and, as shown, it still has to be resorted to either from necessity or convenience.

The method has its value in the very teeth in which its use is least objectionable, namely, the posterior teeth. There is no danger in the use of arsenic in teeth having completed roots or in unresorbed temporary teeth, provided the arsenic be accurately sealed in the cavity so that it does not escape upon the gum. If it does escape it may destroy the gum or pericementum and cause partial necrosis of bone or the complete loss of the tooth together with some bone. The pulp always dies through a process of venous hyperemia induced by the protoplasmic irritant and poison. This hyperemia is progressive from the pulp bulb toward the apex of the root, and there it causes the death of the apical portion of pulp through interference with its nutrition. Sometimes this hyperemia of the pulp extends into the apical tissue, but if the pulp be left *in situ*, necrosis of apical tissue never results, but, on the contrary, the hyperemia becomes resolved after the death of the pulp.

The writer fails to see wherein such a hyperemia differs in consequence from that produced by the surgical removal of a pulp and denominated with favor as surgical pericementitis. In his hands such teeth have given quite as good results as when other methods have been employed.

By this it is not meant that there has been no difficulty in devitalizing some pulps, particularly some of those in which repeated applications of cocain under pressure failed to anesthetize, but that when carefully handled and sufficient time for pulp death has been allowed, careful filling of the canal has been successful.

The rational objections to arsenic, aside from its escape upon the gum, are: (1) The possible production of pain. (2) Possible suffusion of the tooth. (3) The time required.

The production of pain may largely be obviated by observance of certain technique. The pulp should ordinarily be exposed and be slightly bled to relieve any hyperemia or inflammatory engorgement present, as this seems to prevent the absorption of the arsenic. A powerful sedative such as thymol, menthol, cocain hydrochlorid, or morphin acetate should be employed as a corrective, and the menstruum should be sedative rather than coagulant. All pressure on the pulp should be avoided, as this produces pain.

Sufficient time for complete death should be allowed, say, from a week to ten days. If upon examination with a fine smooth broach vitality be discovered, a sedative should be applied and pulp death awaited. Leaving the dead portion against the vital part of the pulp is even better than making a second application, as its removal relieves the congestion by opening the vessels, and the congestion is necessary to the end in view. If the pulp gives but little response upon probing, it may be removed. Sometimes the diapedesis of red corpuscles, associated with the venous hyperemia, causes a staining of the pulp and dentinal fibrils with the liberated hemoglobin. This is unfortunate, but can be treated by bleaching with 25 per cent. ethereal pyrozone sealed in the pulp cavity for about twenty-four hours after the pulp is removed. The third objection, the matter of time, does not apply to the cases of prompt devitalization, as the time spent in pulpal anesthesia and checking hemorrhage is in the aggregate no less than in the arsenical cases. In the delayed action of arsenic the objection is valid, but the apical injection and general anesthesia methods are still open to trial. The arsenical method, of course, requires a longer period of treatment. Pulpal anesthesia can be tried when arsenic does not act well, but should be avoided when it originally failed. As stated, these considerations apply mainly to posterior teeth.

The following is an excellent formula for arsenical paste:

℞—Arsenici trioxidi gr. xv
Cocaini hydrochloridi gr. xx
Thymolis (vel menthoiis) gr. v
Olei caryophylli q. s. ft. pasta—M.

This should be finely ground in a mortar and spread over the bottom of a wide glass jar so that some of the paste may be taken up from the bottom. The arsenic settles to the bottom.

Buckley recommends the following formula:

℞—Arsenic trioxid	gr. 180
Cocain alkaloid	gr. 30
Thymol	gr. 15
Petronal	♏ 15—M.

There are some advantages in the so-called devitalizing fiber introduced by J. Foster Flagg. To make this, absorbent cotton is cross-cut with scissors to a fine lint. This is dusted into the paste or ground up with it in the mortar. It may then be dried on a blotter and be bottled for use. As it lacks long fibers, a small portion may be detached and be placed upon the pulp. There are cases, however, in which the paste should be carried to the exposure upon a probe and gently inducted into a fine exposure. Here its tendency to spread or penetrate is valuable. The fiber has no such tendency, which makes it less dangerous in use. In making the application a minute portion of paste is to be laid upon the pulp, or a pinhead pellet of cotton is rolled in it, the excess of menstruum removed, and it is then applied to the pulp, or a portion of devitalizing fiber is used. This is then sealed in.

The cavity should be prepared for the reception of arsenic, decay being removed as far as practicable.

There are two good methods of sealing the arsenic. In cases not approaching the gum, or where dryness can be maintained, the application may be accurately made and quick-setting cement flowed over it. This cement is capable of being fairly dropped into a cavity or led around the periphery by a probe, and should be very adhesive, also be readily removable. A still safer method consists in applying a pellet of amadou over a part of the pulpal wall. The cement is then introduced about the periphery of the cavity, the amadou being left largely uncovered. When hard, any cement over the amadou is removed and the latter lifted out, thus leaving a box-like receptacle for the arsenic and a pellet of amadou partly wet with eugenol in which menthol is dissolved. When placed, the orifice is dried and more cement added. This method of first making the covering is of special advantage when the cavity cervix is near the gum and prevents the forcing of arsenic toward the gum in the act of making the covering. Amalgam or facing amalgam may be used in place of the cement (Fig. 430).

Fig. 430

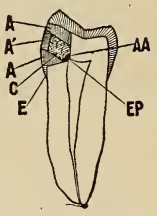


Diagram showing method of first making the covering for an arsenical or sedative application. (See text.) *EP*, exposed pulp; *AA*, arsenical application; *C*, sedative covering to same; *A*, amalgam placed before thes applications; *A'*, amalgam to seal them in; *E*, enamel.

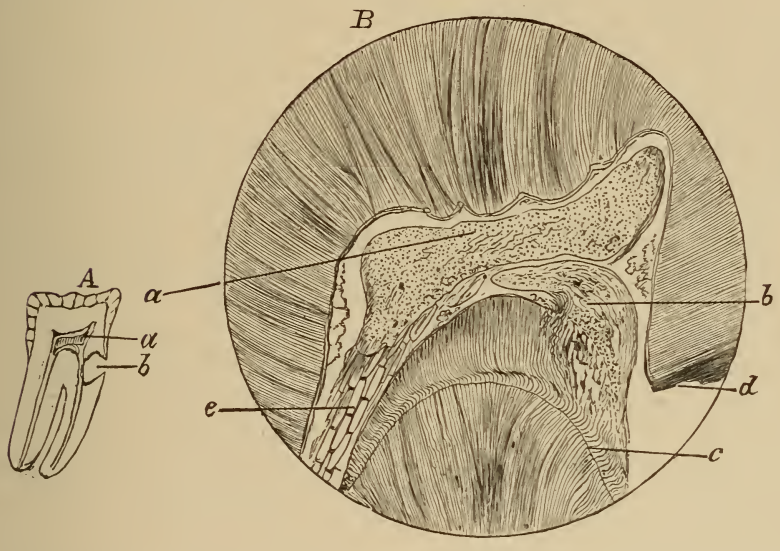
The rubber dam is generally insisted upon, but cannot be used in the worst cases, hence an expert may dispense with it. There is a

tendency among students to rely upon the rubber dam alone to prevent accidents. This is a fallacy, as the same results may occur with it as well as without it. The chief danger lies in the use of temporary stopping after placing paste. Capillarity and pressure often carry the paste to the cervical margin. Making the covering first or using fiber constitute the best precautions.

In case of a very dangerous cavity, as a distocervical one, a special drill pit known as a "pocket" is to be made at some other point extending in the direction of the pulp horn and as near to it as can be made without too much infliction of pain. In this the arsenic is to be sealed while antiseptic sedatives are to be placed on cotton in the cavity of decay.

The presence of pulp nodules may necessitate an application after lifting away the nodule (Fig. 431).

FIG. 431



Calcification of the dental pulp: At *A* is shown the outline of a lower molar with a cavity at *b*. The pulp chamber is much reduced in size and filled with calcific material, as shown in *B*. *a*, *a*, large granular mass of calcific material, which is very transparent but finely granular. A very few irregular lines are seen in the centre, which slightly resemble dentinal tubes; *b*, an erratic growth of irregularly formed and unusually transparent dentin; *c*, line of the growth of dentin from the floor of the pulp chamber—the growth from other directions is so perfectly regular as to leave no markings; *d*, margin of the cavity of decay: *e*, a bundle of cylindrical forms of calcific material extending down into the root canal. These extended to the apex of the root. (Black.)

The arsenical method may be used after a preliminary general anesthesia and bulb removal, or may even be used against an obdurate pulp canal filament.

Symptoms.—The large majority of pulps die under arsenic with but little pain. Sometimes throbbing pain results, passing into a heavy fulness as congestion supervenes. If too great, the pulp should be

uncovered and bled slightly, then a sedative should be applied, iodin used as a counterirritant upon the gum, and pulp death awaited. Ordinarily the pain passes away as the pulp becomes more fully congested. Apical irritation may result and may be ignored if slight, or if severe be treated in the same way as the pulp irritation. A guard to prevent overocclusion is sometimes useful.

Accidents from Arsenical Applications.—These are avoidable, and therefore only occur as the result of carelessness. In very doubtful cases, if a "pocket" cannot be employed the patient should be seen after one or two days for observation of the condition of the gum. It is better that no escharotics have been applied, as confusion may result. The signs of arsenical necrosis at this time are a turgid, purplish, or sloughing gum festoon, and if present this should be freely cut away and the arsenical application should be removed from the cavity.

Any exposed alveolar process should be scraped and the parts should be kept aseptic with hydrogen dioxid. Applications of dialyzed iron or 10 per cent. silver nitrate solution will arrest further necrotic action by forming insoluble arsenites of the respective metals.

If the tooth be lost the alveolus should be burred away to tissue capable of healthy granulation. If bone become necrotic it usually is self-limited, even though it be considerable. The part should be treated as above and the exfoliation awaited with this assurance.

The condition of the roots as to calcification or decalcification may be determined by consulting Figs. 432 and 433; and resorbed or incomplete teeth should not have arsenic placed in them, as the arsenic may pass through the existing end of the root.

Special Methods of Preparing Pulps for Removal.—When in the course of extirpation a vital apical remnant is found, carbolic acid may be instilled into it with a fine, well-sharpened Swiss or other smooth steel broach. The canal is flooded with the phenol and the broach is to be repeatedly but gently yet progressively thrust into it, carrying with it some carbolic acid. Forcibly pressing the phenol into the pulp filament under a mass of unvulcanized rubber, as in cocain pressure anesthesia technique, will usually desensitize the filament and facilitate its removal without hemorrhage.

A hot Evans' root drier may be quickly thrust into it. This does not necessarily give much pain. Tightly packing a thread of cotton saturated with carbolic acid against such a filament and leaving for a few days will sometimes induce thrombosis and death of the pulp.

When a tooth has been fractured or excised, or when the pulp is fully and widely exposed in a single root, a Portuguese toothpick finely whittled and previously soaked in carbolic acid may be quickly thrust into it, thus "knocking out" or crushing out its vitality, so suddenly as to prevent much painful response. If the removal of the stick does not bring the pulp with it, it should be broached out.

Devitalization of Pulps in Temporary Teeth.—All of the anesthetic measures are as applicable to temporary teeth as to the permanent ones if the little patient will tolerate their application.

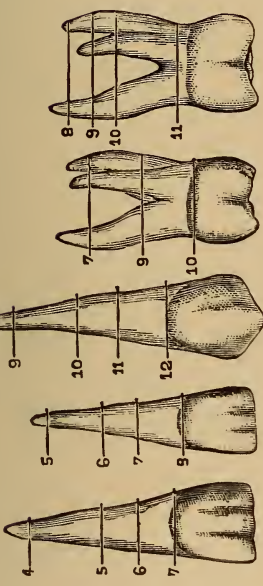


Fig. 432

Decalcification of the deciduous teeth. The numbers indicate years. (Peirce.)

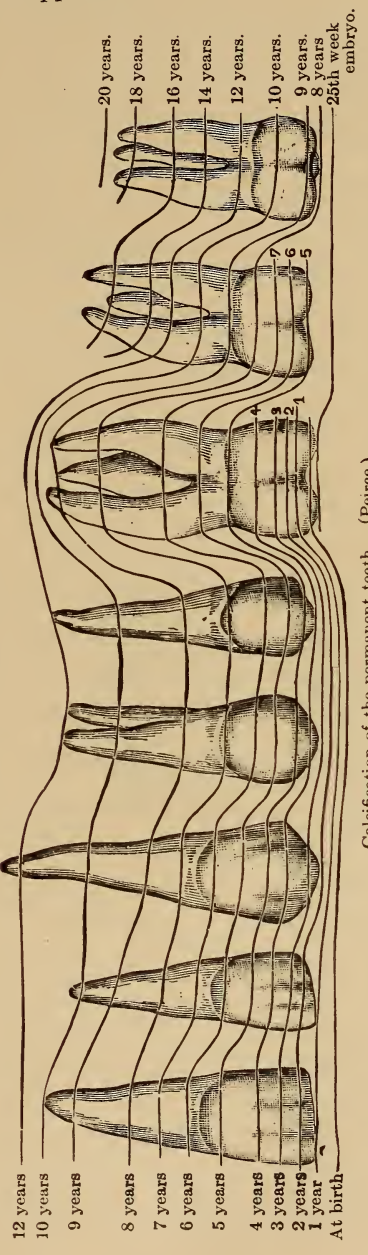


Fig. 433

Calcification of the permanent teeth. (Peirce.)

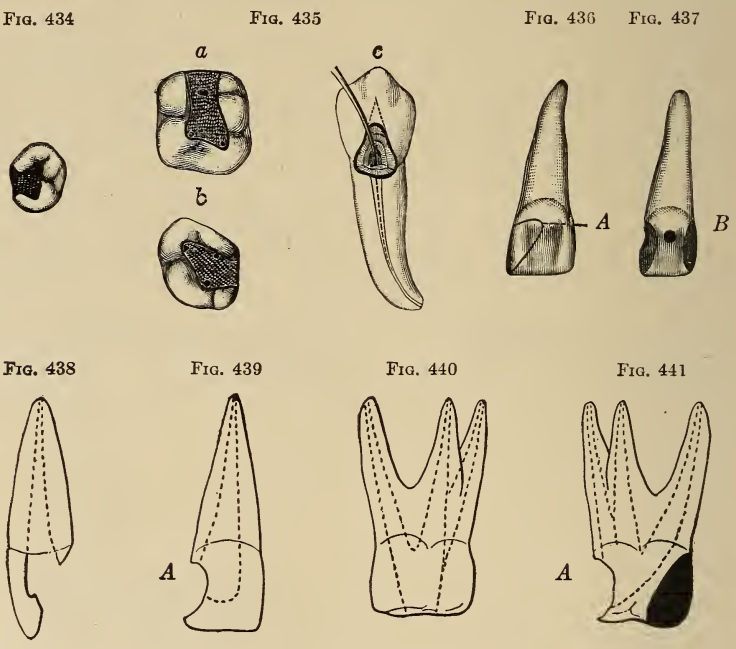
If the child present an exposed pulp in a tooth the roots of which are not resorbed, arsenic much diluted may be applied for twenty-four

hours and then be removed, the pulp being then allowed to die. When roots are resorbed it is better to cap the pulp with Jodo-Formagen cement, or if necessary apply a pellet of cotton wet with phenol, then touched to iodoform and seal in with temporary stopping, making a slight pressure. This may remain a week or more and be renewed if necessary.

Darby has used cantharides, $\frac{1}{20}$ grain in carbolic acid, with success. It must be carefully sealed, as strangury is a possibility.

THE EXTIRPATION OF THE PULP

After the pulp is prepared for removal or the patient is anesthetized free access to all parts of the pulp cavity and canals must be obtained. This is usually best accomplished by an opening made in direct line with the axis of the pulp canal. In general terms this involves for sound teeth an opening upon the lingual surface of incisors and cuspids and upon the occlusal surface of bicuspids and molars.



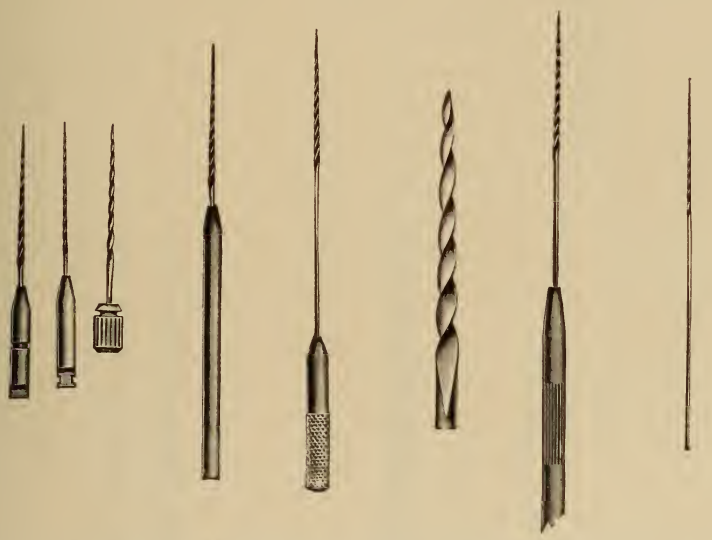
This access may consist of a new opening or an extension of a cavity, or at times the cavity and canal may simply be made continuous.

When a cavity of decay exists the pulpal wall should be perforated and a large bud bur should be used to cut away the dentin overhanging the pulp cavity. It is usually necessary to extend the

cavity in the central occlusal direction, so as to permit direct access to each canal (Figs. 434 to 440).

When a tooth crown would be irremediably weakened by such a course, a slight indirectness is permissible when flexible cleansers can be used instead of drills. This leaving of tooth structure should be done with judgment. The canals must be cleansed. In cavity approaches the *outer* wall of the pulp cavity should be cut away to permit an obtuse-angled approach rather than a right-angled one (Figs. 439, 441, *A*). All pulp cavity corners should be burred to a shape that obviates retention of pulp debris, the subsequent decomposition of which would lead to discoloration. The opening shown in Fig. 437 is faulty for this reason, and is better if extended more toward the incisal edge, making an oblong opening with rounded ends.

FIG. 442



Kerr or Downie broaches. Various finer sizes of these broaches and reamers may be had. They should have accurate taper.

In sound teeth the entrance to the canal is made with a small spear drill, after the enamel has had a "spot" made in its surface with a sharp dentate bur. This centres the spear drill and prevents its slipping about. After it has entered the pulp cavity dentate burs are used to enlarge the opening to the desired size and shape. A sawing motion creates more rapid clearance and cutting of tooth tissue.

One should not always suppose that the spear drill will drop into an appreciable pulp cavity. The careless driving of a drill into a tooth may cause a perforation. Secondary dentin or a large nodule and, in previously treated teeth, zinc phosphate may occupy the pulp chamber. Therefore, when doubt arises, open well that portion of tooth or filling

which has been drilled through and note the conditions, then go ahead carefully. In opening a located pulp chamber with burs a bud bur is very useful, but all burs once placed through the drill hole and into the pulp chamber must be used laterally or the heel of the bur used with an outward sweep toward the occlusal aspect for the sake of safety.

The canal (or canals) is now to be explored, and if of operable size a Donaldson cleanser or barbed broach is passed to the canal apex, twisted so as to engage its teeth with the pulp substance, and the pulp extirpated.

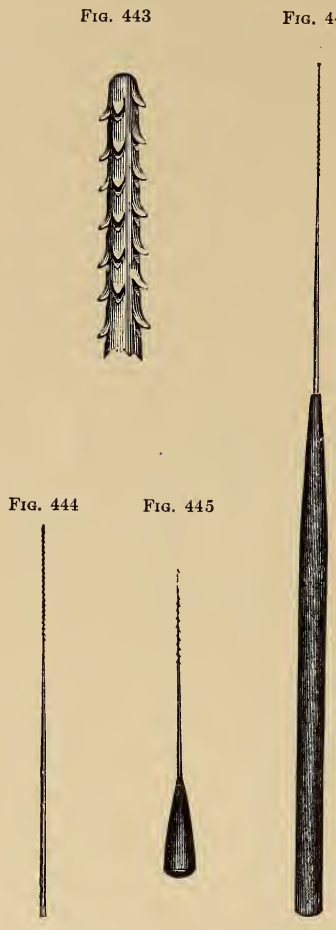


FIG. 443 FIG. 446 FIG. 444 FIG. 445

Dr. Donaldson's pulp-canal cleansers.



FIG. 447

Dr. Donaldson's spring-tempered nerve bristles.

If there be any difficulty in finding the canals after this preparation, by reason of the broach catching on the edge of the orifice, the mouth of the canal should be made continuous with the wall of the pulp chamber by means of a small bud bur. The wall then leads the broach into the root lumen.

In single-rooted teeth with finer apices a fine Kerr engine root reamer (Fig. 442) may be passed by hand to the apical portion of the root and gently rotated. It is then mounted in the hand piece, passed gently to the apex, slightly withdrawn, and then operated by engine power. It is pressed lightly laterally to enlarge the canal slightly. The next larger size is then used in like manner, and finally the larger admissible sizes. This gives a beautifully tapered canal form useful in canal filling and for the adaptation of dowels. The pulp is simultaneously removed, generally being churned out of the root, and danger of false openings is avoided. A final exploration and apical scraping may be given with a fine Donaldson cleanser (Figs. 443 to 446) and the pulp cavity corners rounded out with burs.

This technique is only admissible in cases of openings in line with the pulp axis. Those almost in such line may have the flexible sizes of Kerr reamers so used, all apexward pressing and reaming to be done by hand at first. When general anesthesia is employed it is better to open roughly, then pass a fine Donaldson cleanser, which has been previously dipped in carbolic acid and laid aside in readiness, to the apex of the root canal. It is given a few turns to engage the pulp, and the latter is lifted away. The other work is to be done upon return to consciousness.

As the Kerr broaches and reamers are made of a variety of forms, it should be stated that only those which have a gradual taper from point to shank can be relied upon to satisfactorily carry out this technique. In these the successive sizes follow one another without danger of perforation of the canal walls.

It is sometimes better to drive a fine hand Kerr broach to the canal apex, and, if the engine broach be not permissible, to continue with the different sizes of hand broaches. One soon obtains a familiarity with the canal curve and size when working with the hand, which gives confidence and safety when later working with engine power.

In molar teeth and upper first bicuspids, after the pulp chamber has been prepared, the canals are to be located with a fine smooth broach or a Kerr broach. The finest root reamer is then used by hand and gently twisted and forced apexward into each canal in turn. The next smaller is then used. As these canals are normally somewhat curved, only flexible forms should be used unless the larger size follows readily the rather curved canal made by the previous one. Following this, Donaldson cleansers are operated by hand to scrape the sides and inequalities of the somewhat flattened canals which the reamers have not reached (Figs. 448 to 451). When the finest Kerr reamer does not explore the canal properly, owing to constrictions, a drop of 50 per cent. sulfuric or pure lactic acid in water is introduced into the canal and a smooth, fine, spring-tempered Swiss broach is used to gently enlarge it by drawing it back and forth in the canal. Then a fine Donaldson cleanser is to be used in the same manner; later the larger sizes are

used. If feasible, the Kerr reamers may now be used, when direct access is had. If the access be indirect the Donaldson cleansers only should be used.

Some operators prefer the use of the alloy kalium-natrium, used on the broach as a means of facilitating the opening of the canals. If acid be used it should be neutralized with sodium bicarbonate or sodium

Fig. 448

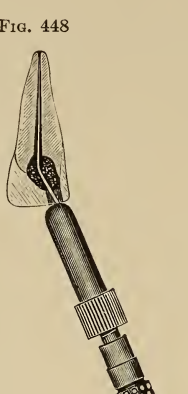


Fig. 449

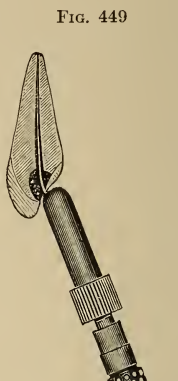


Fig. 450

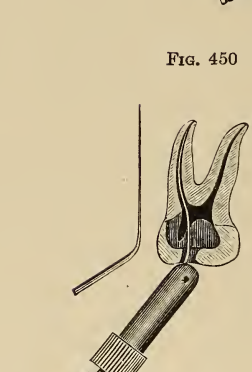
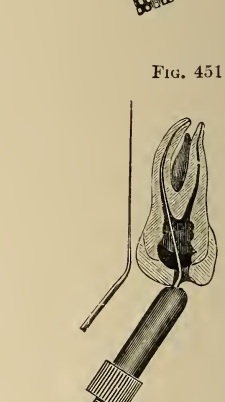


Fig. 451



dioxid. The improved Gates-Glidden drill (Fig. 452) has some use in the enlargement of canals the lumen of which has been determined by the above methods. They should not be used for the preliminary opening of fine canals, as they tend to form false channels in the side of the canals which constantly catch even fine bristles and may render a canal into a form even less advantageous than that it already possesses. The canal filament of pulps in molars and upper first bicuspids may be

lifted away with barbed broaches or cleansers if the canals are large, but it is ordinarily a waste of time to attempt it in the finer canals, as the other work must be done in the apical regions.

This technique is, as a rule, best carried out under rubber dam, to prevent the septic contamination of canals by entrance of infected saliva; but if this be impossible it is wise to sterilize the mouth and napkin it, and to place a drop of carbolic acid or formocresol in the canals and continue the work under *antiseptic* precautions.

It is wise to have the patient first brush the teeth, using soap or a tooth paste or powder. After application of the dam or napkin the cavity is cleansed of the debris of decay if any be present. Then the cavity is to be wiped out with phenol-camphor. Next the application of cocain, etc., is made. Before entering the pulp chamber or just after, a drop of formocresol is to be placed on the field of operation and a clean bur used to enter the pulp cavity. The debris is removed, the canals located, and a fresh drop of formocresol placed before continuing with the canal work.

FIG. 452



Improved Gates-Glidden nerve-canal drill for engine work.

As the napkins become wet they may be removed, the cavity douched with a jet of warm water, the patient rested for a moment, and then the napkins are reapplied, the cavity dried, and the operation repeated. The napkins may be renewed without disturbing the treatment, but it is often desirable to wash out the debris, and the rest is often agreeable to the patient.

The scraping of the canals removes the possible remnants of pulp tissue, odontoblasts, etc., adhering to the dentin walls, and also a part of the wall with the large ends of the fibrils. All these are decomposable media, may become septic, and are wisely removed.

The final removal of all pulp debris, coagulated blood, etc., is best done with a fine Donaldson cleanser moved to and fro in the canal with one hand, while with the other a stream of warm water is gently introduced by means of a Moffat syringe. A large cottonoid roll or a napkin may be held by the patient or assistant to absorb the excess of moisture when the rubber dam is in position.

The carrying out of canal treatment involves a knowledge of the topographical anatomy of the teeth and their pulp canals. As an aid to this Figs. 453, 454, and 455 are introduced, showing the normal outlines of the teeth and their pulp chambers. Fig. 455 shows the appearance and locations of the pulp canal openings at their coronal ends. It is to be borne in mind that the roots are not always normal in shape, as shown in Figs. 456 to 489, and that various degrees of lack of development or resorption may cause the root canals to be unusually

DESCRIPTION OF FIGS. 453, 454 AND 455

FIG. 453.—Fig. 3 gives in contrast a sectional view of deciduous and permanent upper teeth divided through their lateral diameters.

Fig. 4, a sectional view of the corresponding lower teeth divided through their antero-posterior diameters. *a, b, c* represent, respectively, the deciduous and permanent front incisors in contrast: *d, e, f*, the lateral incisors; *g, h, i*, the canines; *k*, deciduous molars, upper and lower; and *l, m*, the successors to the deciduous molars, the bicuspids; *n, o* represent permanent molars. *c, f, i, m, o* have dotted lines indicating the thickness of enamel removed by wear, atrophy of the cementum, and reduction in the size of the pulp due to progressive calcification, these changes being incident to old age.

FIG. 454 represents in Fig. 1, letters *a* to *h* and *a* to *h*, the longitudinal or vertical sections of the sixteen upper teeth, showing the labio-palatal diameter of the pulp chamber and canal in crown and roots, the section of the molars being through the anterior buccal and palatal roots, while the bicuspids *d e* and *d e* illustrate the result of such a compression of the root as to divide the pulp chamber into two canals—a condition which so frequently exists in these flattened roots. The double-lettered series, *d d* to *h h* and *d d* to *h h*, represent in the molars a section through the posterior buccal and the palatal roots, from which is quite readily recognized the slightly greater lateral diameter of the pulp chamber in the crown and the larger canal in the posterior buccal root over that in the anterior buccal root, while the bicuspids lettered *e e d d* and *d d e e* illustrate a modified pulp chamber and canal, with bifurcation of the root in one, these being cut through a different axis or plane from the single-lettered series.

Fig. 2, letters *a* to *h* and *a* to *h*, represent the sixteen lower teeth with the section through their long diameters, as in the upper series. These incisors illustrate the compressed or flattened condition of their roots in contrast with the cylindrical character of the roots of the upper incisors, while the bicuspids *d e* and *d e* illustrate the singleness of their pulp chamber and the cylindrical condition of their roots as in contrast with the flattened or compressed condition of the roots of the upper bicuspids. The molars *f, g, h* and *f, g, h* represent sections through the anterior root, illustrating its compressed condition and divided pulp chamber in the first and second molar, and a somewhat flattened one in the anterior root of the third molar; *f f, g g, h h* and *f f, g g, h h* represent the single and cylindrical pulp chamber in the posterior root of the lower molars, while *b b, c c* and *a a, b b* represent the incisors and canines of the same series, with modified pulp chambers arising from modified development.

FIG. 455.—Fig. 1, from *a* to *h* and *a* to *h*, represents the upper teeth, with transverse or horizontal section through the base of the pulp chamber in the crown, viewing the entrance to the canals of the several roots, while the same letters in Fig. 2 represent the lower series in the same manner.

Fig. 3 represents the upper teeth, with the transverse or horizontal section made below the largest diameter of the pulp chamber and through the canals after they have diverged from the central chamber, but before the roots into which they run have in the molars bifurcated.

Fig. 4 in like manner represents the lower series, well illustrating the flattened or compressed condition of the canal in anterior roots of the molars and the division of the chamber, as is frequently found in the roots of the lower incisors.

The letters *a a, b b, c c, d d, f f, d d* and *e e* (Fig. 3) represent the relative shapes, whether circular, oval, or flattened, of the pulp canal in the roots of the upper central and lateral incisors, the canines, the first and second bicuspids, and the first, second, and third molars, while the same letters in Fig. 4 represent the relative shapes of the pulp canal in similar teeth in the lower series.

[1] These figures are taken from v. Carabelli's *Anatomie des Mundes*.

Fig. 453

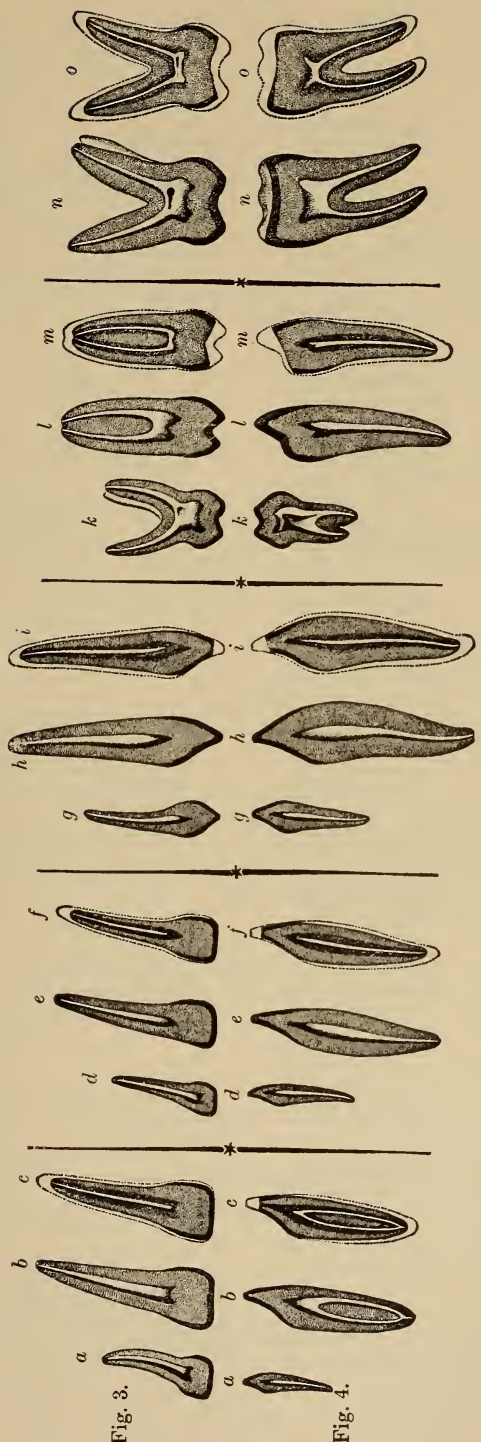


Fig. 3. Fig. 4.


Fig. 1.
Fig. 2.
hh gg ff ee dd c b a a b c dd ee ff gg hh
h g f e d c b a a b c d e f g h
h g f e d c b a a b c d e f g h
hh gg ff cc bb aa bb ff gg hh

Fig. 454

FIG. 455



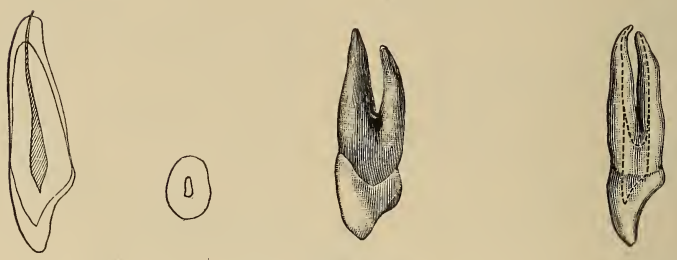
open or short with the treatment complicated by the presence of vital tissue at the root ends. In a general way it may be stated that much

Fig. 456 Fig. 457 Fig. 458



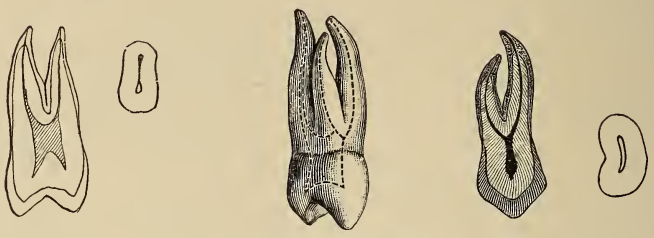
Upper lateral incisors. (Ottolengui.)

Fig. 459 Fig. 460 Fig. 461



Upper canines.

Fig. 462 Fig. 463 Fig. 464



Upper first bicuspids.

Fig. 465 Fig. 466



b a b a

Upper second bicuspid. Upper first molar.

resorbed roots, as indicated by the age in deciduous teeth, or largely incomplete roots, as indicated by the age in permanent teeth, indicate

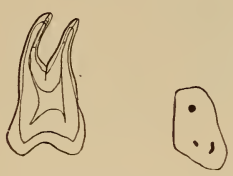
a pulp capping operation rather than extirpation; in the permanent teeth, to permit better root formation. If unavoidable, one must do the best possible (see Figs. 432 and 433).

Fig. 467



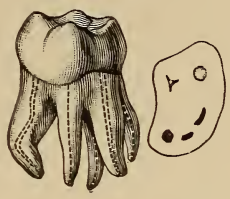
Upper molar.

Fig. 468



b *a*

Fig. 469



b *a*

Upper second molars.

Fig. 470



Fig. 471



Fig. 472



Fig. 473



Fig. 474



Fig. 475



Upper molars. (Ottolengui.)

Fig. 476



a



b

Upper third molars.

In the penetration and enlargement of canals the larger and straighter canals may be cleansed thoroughly to the apex, but in very fine and tortuous roots (Figs. 456 to 489) the operator is often confronted with the option of taking the chances of perforation by forcing further

entrance or of leaving some doubtful apical portion uncleansed. The decision should be that the danger of perforation is the greater evil, and agents of a mummifying character should be employed to render any

FIG. 477



FIG. 478

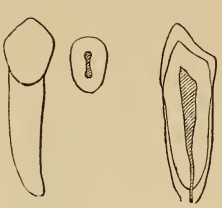


FIG. 479



Lower incisors and canine.

FIG. 480



Lower first bicuspid.

FIG. 481



Lower second bicuspid.

FIG. 482



FIG. 483

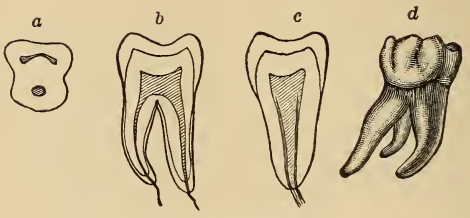


FIG. 484



Lower bicuspids.

FIG. 485



Lower first molars.

such filament into a state lessening the danger of subsequent putrefaction.

The writer regards the use of formocresol (equal parts of 37 per cent.

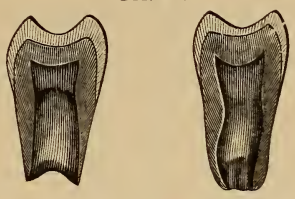
aqueous formaldehyd solution and cresol) as especially valuable where immediate root filling is not indicated. If the patient be of nervous and irritable type this may be diluted to 5 or 10 per cent. formaldehyd

Fig. 486



Lower first molar.

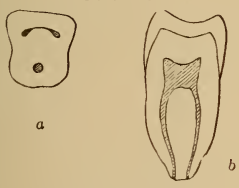
Fig. 487



Lower first molar, immature.

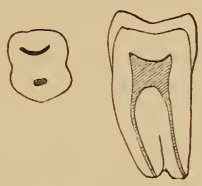
strength by the use of cresol or camphophenique without impairing its value. Often the full strength may be used on cotton as a temporary

Fig. 488



Lower second molar.

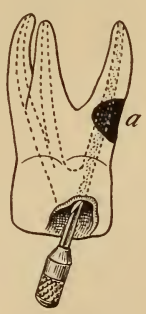
Fig. 489



Lower third molar.

dressing. This hardens any remaining pulp and also probably the fibrils in the tubules. It also permits the apical tissue to heal and resume its normal sensitivity when the pulp has been entirely removed, which is of value in determining the extent to which pressure may be applied in filling the canals.

Fig. 490



Method of restoring lost canal continuity. The cavity should have more retention form than shown.

In a few cases in which cervical cavities obliterate the canal or cause annoying approach to it, it is desirable to remedy the condition. In such case the canals are opened as usual and enlarged, and the cavity prepared with suitable retentions for filling. The last-used reamer is then to be placed in the canal and the filling inserted. The filling is then supported by pressure while the reamer is slowly twisted to the right and withdrawn, leaving a canal through the filling. This may be done with amalgam or with zinc phosfate if a later removal be required. If the root be much weakened, a tapering dowel may be cemented through the crown and canal, thus attaching the root to the crown more firmly.

ACCIDENTS IN CANAL OPENING.

The chief accidents that may occur are the perforation of the root wall and the breaking of the instruments used. If the technique laid down be carefully followed the danger of perforation is practically eliminated. In fact, the greatest danger is the penetration and enlargement of the apical foramen. To avoid this the Kerr reamers should always be passed to the apex of the canal by hand or while the reamer is not revolving. It is then withdrawn a trifle and revolved, and one may always judge the distance the reamer was withdrawn. Accidents are usually the result of thoughtless forward pressure of reamers and drills, and care will reduce this to a minimum. Sometimes one must take the chances with the Kerr engine reamer. When doubt exists as to canal locations, the desiccation of the pulp chamber is of great assistance by bringing them into view, and if secondary deposits exist one should always use a small bud bur and keep well within the limits of the dentin of a root while gently seeking a canal lumen.

Frequent exploration should follow gentle advances, and, as a rule, the canal will be found of fairly normal size just beyond the point of constriction. In some cases 50 per cent. sulfuric acid should be sealed against the suspected canal and the operation deferred to another sitting.

If a perforation be accidentally made it should be covered as in any case of perforation (which see).

Always one should be able to diagnosticate such an opening, and arsenic should never be applied to such. Cases of extensive necrosis have occurred from carelessness in this direction. The breakage of broaches is largely avoidable through the use of new instruments and by adhering to the rule of using the smaller sizes until the canals are sufficiently enlarged to permit the use of larger sizes, and, in case of engine reamers, of starting the power with the reamer loose in the canal.

The engine broach seems to be of better temper than the engine reamer.

Accidents of this sort usually occur with barbed instruments of the Donaldson cleanser type, especially when used with force. Sulphuric acid tends to disintegrate the broach, so that lactic acid is often better used with it, or the alloy of sodium and potassium with a smooth broach will open the canal so that the cleanser will not bind. If it bind it should be grasped with the thumb and finger and given a straight pull.

While avoidance is far better than the application of the remedy, if the accident occur, the broach should be removed if possible.

If lying loosely in the canal a new cleanser may be passed to one side of it and then be pressed against it. It should engage the barb and jig it out.

Cotton wrapped on a small Swiss broach may be pressed down at one side of the broken broach and its fibers made to engage its barbs.

Moving the broach back and forth, while sulfuric acid, sodium dioxid, or sodium and potassium is about it, will sometimes loosen it. One may sometimes drill to one side of a broken instrument with a Kerr engine broach in order to more readily engage it with a barbed instrument. If very loose a magnetized probe will attract it and draw it out.

If the broach be tightly fixed in the canal, sodium chlorid, tincture of iodin, sulfuric acid, aqua regia, or 25 per cent. pyrozone may be sealed in, in the hope of chemically disintegrating it.

The head of a Gates-Glidden drill or Kerr reamer is treated in the same manner.

If any broach be irremovable, iodoform paste or embalming paste should be packed over it and sealed in, in order to keep the parts permanently sterile. In a septic case the formocresol treatment should precede such root filling (see p. 401).

For root filling, see p. 456.

CASES IN WHICH THE PULP IS DEAD

There are several classes of cases requiring root canal treatment in which the pulp is completely necrosed when the patient presents, and in all but one of these the pulp is in a putrefactive condition. Therefore the consideration of the treatment may be taken up under the following headings:

1. Cases in which the pulp is in a state of dry gangrene.
2. Cases in which the pulp is in a state of moist gangrene but no evidence of acute pericementitis is present.
3. Cases in which the pulp is in a state of moist gangrene and subacute or acute septic pericementitis is present.
4. Cases in which the pulp is in a state of moist gangrene and a fistula upon the gum or other part is evidence that there has been an acute abscess which has passed into the chronic or discharged state.

Dry Gangrene.—By dry gangrene of the pulp is meant its total death under aseptic conditions, and the absorption of its moisture, leaving a tough shrivelled mass (Fig. 491). This condition is very rare as a spontaneous occurrence, but no doubt has been frequently induced by the application to pulp stumps of mummifying preparations containing paraformaldehyd, alum, tannin, or zinc chlorid; indeed, this is the intent of the so-called mummifying pastes. The conditions favorable are: (1) Pulp death from some aseptic cause, such as the hyperemia resulting from a blow on a sound tooth. (2) The constriction of an apical foramen, as by hypercementosis, the result of thread biting or other

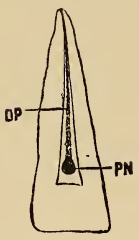
mild irritation of the pericementum. (3) The exhaustion of the pulp due to secondary dentin, which may protect it from subsequent infection. (4) The capping of the pulp with agents having a mummifying and also antiseptic action (which includes such treatment of pulp stumps). The former practice of using zinc oxychlorid and the present use of Jodo-Formagen may have such action if the pulp undergoes irritation and death in spite of the cap.

The tooth may have a good color, the dentin will be insensitive, but without odor, and there will be no odor or fluid in the pulp canal. The final diagnosis can only be made when the pulp is found in the shrivelled state. This is of very rare occurrence, odor almost always being present.

Treatment.—The tooth should be opened and the pulp lifted away under the antiseptic influence of a formaldehyd solution. The canals are to be opened as in any case of vital pulp.

Moist Gangrene Without Pericementitis.—The death of the pulp through venous hyperemia or inflammation leaves it full of moisture. If saprophytic organisms gain entrance, it undergoes decomposition through putrefaction or fermentation into a series of compounds simpler in chemical structure than its own proteid compounds. Albuminous substances putrefy with the formation of (1) peptones, and (2) ptomains or animal alkaloids, such as putrescin, neuridin, and cadaverin, which are stated to be capable of pus formation in vital tissue when free from bacteria. Next, nitrogenous bases, leucin, tyrosin, and the amines; also organic acids. Next, aromatic products, indol, phenol, cresol, and finally hydrogen sulfid, ammonium sulfid, carbon dioxid, and water. The end products account for the presence in decomposing pulps of

FIG. 491



Dry gangrene of the pulp: *PN*, pulp nodule; *DP*, shrivelled pulp. (From a specimen of pulp extracted intact in this condition.)

FIG. 492

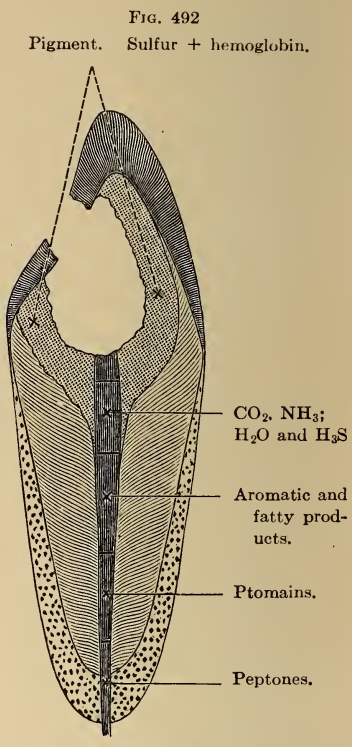


Diagram illustrating the more complete decomposition of the pulp at its coronal end.

malodorous gases and moisture (Fig. 492). "Fermentation and putrefaction can only occur where the fungi concerned live and the extent of decomposition is conditioned by the number of fungi."[1]

In its clinical aspect a putrefactive pulp is of the yellow color of sloughing tissue with a reasonably tough consistence, less than the normal, however, which indicates recent gangrene with beginning decomposition. It next passes into a jelly-like consistence, and finally into gases and water. Naturally the greatest number of fungi will have by multiplication invaded that end nearest the source of infection, the mouth or cavity of decay, while the more consistent portion of the pulp will exist at the apex. This is exactly what is found clinically in cases seen at the right time. Of course, total decomposition into gases and water may occur, so that the canal may appear empty or nearly so, yet odor can generally be found, as even tubular contents decompose and the tooth structure is saturated with the end

Fig. 493



Sector of a cross-section from a diseased root: *a*, cementum; *b*, stratum granulosum; *c*, very narrow and finely branched tubules; *d*, penetration of bacteria into tubules. × 150. (Miller.)

Fig. 494



Dentin from the root of an abscessed tooth, showing the penetration of cocci to a depth of about $\frac{1}{10}$ mm. ($\frac{1}{250}$n in.), the side *a-b* bordered upon the canal. × 1000. (Miller.)

Fig. 495



Skiagraph of unfilled root canals with large mass of filling material built in over them. (Price.)

[1] Ziegler.

products (Fig. 493). As the pulp decomposes, the H_2S combines with the NH_3 of proteid origin to form NH_4HS or $(NH_4)_2S$, which in turn combines with the iron of the hemoglobin, forming Fe_2S, which darkens the tissue. Partial gangrene, the apical portion of a pulp being vital, is sometimes seen, and sometimes one canal filament will undergo decomposition and even produce an abscess, while another or two other filaments remain vital.

As these gangrenous pulps often produce apical abscesses, they must contain pyogenic organisms; still, abscess and ulceration in which the pulp body undergoes putrefactive decomposition, with formation of pus, is not necessarily gangrene, but rather a necrobiotic process.

Arkövy found that pulps infected with the Bacillus gangrenæ pulpæ in pure culture would undergo total gangrene without suppuration, while when infected with mixed cultures or even pleomorphic forms of the Bacillus gangrænæ pulpæ chronic pulpitis was produced. If the mixed culture contains pyogenic bacteria it is plain that the chronic pulpitis may be suppurative.

Gangrenous pulps do not necessarily produce abscesses at once, but often clinical history shows that a year or two, or even more, may elapse, though as short a time as two or three weeks has sometimes been sufficient. In one case of a boy, aged ten years, the time between a capping of a bleeding pulp with Jodo-Formagen and the presence of a fistula upon the gum was but two weeks. It was, however, in a temporary first molar, and the cement covering the cap was found to be loose.

The forcing of gangrenous pulp tissue by instrumentation into apical tissue generally results in an abscess, even when extraneous bacteria are presumably not introduced.

The irritating substances in a decomposing pulp are presumably the bacteria, the ptomains, and the expanding gases.

Many decomposed pulps produce no pain, but in these cases the gases may escape *via* dentinal tubules and leaks about fillings (Fig. 495).

Clinically, putrefactive pulps may be found in sound teeth, in filled teeth, and in teeth the pulp cavities of which are open to the oral fluids either actually or through the medium of open tubules in the dentin over them, or in apical portions of poorly cleansed or partly filled canals. A cotton dressing having a bad odor, or an apparently empty apical portion of canal or a leaky gutta-percha canal filling associated with a bad odor, even though the pulp has been successfully removed, have a similar pathology. There is little difference in principle between putrefactive serum or tubule contents and a putrefactive pulp. Any of these may cause abscess or remain quiescent.

Symptomatology.—The symptoms are opacity of the tooth evident to the eye or noted by transmitted light, discoloration of varying degrees, odor and discoloration of the dentin in a cavity.

There is a lack of response to cutting, thermal and electric tests.

Sometimes a bad taste due to leakage is present. Looseness, tenderness to percussion, incipient and acute abscess, and a chronic fistula are evidences of pericemental irritation.

Pain to heat, while usually indicative of pulp irritation, also sometimes occurs, and is explainable upon the same theory of the expansion of gases against vital tissue—in this case the apical tissue. These symptoms are all explained by the pathology of the condition.

Treatment.—The pulp being presumably infected, all quiescent gangrenous pulps or putrefactive conditions under any conditions, discovered indicate a similar treatment, namely, first disinfection to remove or kill bacteria which might cause an abscess and at the same time to destroy the chemical nature of the gases and ptomains. After this the canals are to be thoroughly opened.

Three substances are preëminent in this direction—(1) formaldehyd, (2) nascent oxygen, (3) iodin or its derivatives.

At the present writing no substance equals formaldehyd, because of its rapid diffusion through all canals, tubules, and even abscess tracts.

The first and best treatment consists in opening the pulp cavity and gently removing the bulk of decomposed pulp from the pulp chamber and canals, care being employed to avoid forcing any putrid material into the apical tissue by broaching or plunging of the bur. Also, no bacteria should be introduced from outside. The opening should not be too freely made, and should be funnelled or countersunk outwardly to secure the seal against being plunged into the pulp cavity in mastication (Fig. 496).

This being done, the canals are dried with cotton and hot air, and a small pellet of cotton saturated with formocresol or 10 per cent. aqueous formaldehyd solution is to be placed in the pulp chamber. Any that has come in contact with the orifice should be removed with alcohol. The orifice is then dried and a small piece of dry spunk placed over the application, but not so as to interfere with the seal. Quick-setting, adhesive, hydraulic cement is now flowed into the orifice, air bubbles being avoided by flowing it in with an instrument. A bit of paraform accomplishes the same purpose as the solution, namely, the liberation of formaldehyd gas.

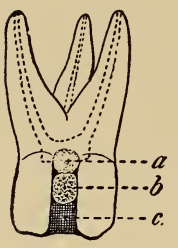
When opportunity for self-relief seems proper, as when the operator is leaving his practice for a short time, or may otherwise be inaccessible, hot temporary stopping may be used and the patient instructed as to the proper procedure to obtain relief. An ordinary pin crooked at the point by striking it across any hard surface will serve to pick out the stopping and cotton. In all cases tight coverings must be made, as the object is to concentrate the action of the formaldehyd gas upon the canal and tubular contents.

In some cavities it is well to make the covering first, as done for arsenic (see Fig. 430), and to seal the dressing in with a further addition of

cement or temporary stopping. The latter does not permit mastication like the former.

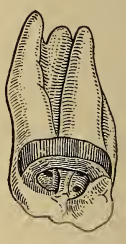
If there be a broad cavity extending beneath the gum, it is well to press the gum away with cotton pellets, then to form the cavity and open the canal orifices. Then a retention at the cervical portion of the cavity should be made, even if it be necessary to drill a series of pits along it with a No. 1 bur. Spunk is now placed over the pulp canals and quick-setting amalgam is to be permanently built in at this part of the cavity. When set the spunk is withdrawn, formocresol in cotton is inserted instead of the spunk, and the covering completed with cement. The amalgam is finished as far as practicable at the one sitting and the case dismissed. At future sittings rubber dam may be applied and the canal work done (Fig. 497).

Fig. 496



a, cotton and formocresol; *b*, spunk, *c*, cement.

Fig. 497



Cervical wall built up with amalgam to permit canal sterilization and treatment.

Formocresol consists of equal parts of 37 per cent. aqueous formaldehyd solution and cresol, which combine well.

According to Buckley, the formaldehyd not only acts as a germicide, but combines with the ammonia of ammonium sulfid to form urotropin and with hydrogen sulfid to form methyl alcohol and sulfur. The cresol is supposed to act upon the fatty compounds, changing them into a compound resembling lysol. Thus, antiseptic substances are formed from poisonous ones. Formaldehyd is so efficacious in the writer's hands that it has displaced other methods in his practice. All other methods of disinfection produce results less certain than those produced by it and are more cumbersome, therefore they will be here dispensed with. While this is true for a great majority of the cases, occasionally a patient is met with whose tissues do not tolerate formaldehyd well. Formocresol then should be reduced to a 5 per cent. solution with cresol or phenol-camphor, and in some cases abandoned for more sedative antiseptic remedies, such as eugenol or phenol-camphor with menthol.

This first dressing may be left for from twenty-four hours to a week, or longer if the patient is comfortable.

At the second sitting the rubber dam is to be applied and the canal opening thoroughly made under formocresol influence, just as though the pulps were vital, the technique differing in no respect. A second dressing is introduced into the canals. Whether this shall carry the full strength formocresol or it shall be modified by the addition of cresol or phenol-camphor depends upon the history of any irritation or perfect comfort as a result of the first application. The object of a second dressing is to determine whether the odor (gases) has been discharged from the tubules. When the dressing has absence of putrefactive odor, no pus can be detected, and the patient is comfortable, the canal is ready for filling. Less than this result is too soon, and delay beyond this is a loss of time.

When one pulp filament is gangrenous and another vital, the treatment is the same, it being the writer's experience that formocresol loosely placed is not incompatible with ulcerated pulps, and, indeed, is an excellent dressing for suppurative pulps when modified to a 3 to 5 per cent. strength. Later, the vital portion is appropriately removed.

When apical pericementitis of a subacute nature is present on a filled tooth, as when a tooth shows some looseness and tenderness, with some injection of the gum, all faulty root canal fillings should be removed with barbed broaches, cleansers, or root reamers, and the case is then resolved into one of moist gangrene and treated accordingly.

If a cotton root filling be found it sometimes allows the broach to tear loose. In such case a Kerr broach is driven into it to create a central opening, after which the fibers become engaged by the barbed broach.

Eucalyptol may be used to soften gutta-percha root canal fillings, and at times the smallest Kerr or Downie broach is to be bibevelled at its end and used as a drill cutting its way. Oxychlorid and other cement fillings may have 50 per cent. sulfuric acid or strong ammonia water applied to them to assist in breaking up the bond of the cement by chemically destroying either the zinc oxid or the acid. The drill will tamp the fluid into the cement and cut the cement at the same time.

All root fillings of cement nature are apt to be faulty when used as such, because the air in the canal prevents ingress, though it may appear to be well filled. This fact is of importance in diagnosis in filled teeth, giving evidence of chronic pericementitis, *i. e.*, there is probably an unfilled portion of root canal containing putrefied pulp or serum.

It is a weakness of good operators, if not of all, to think that their individual canal fillings are perfectly made. The writer was once associated with a most conscientious man, and possesses a gutta-percha canal filling of his in a molar now successful for twenty years. On one occasion he declared that he had filled perfectly a canal of an upper second bicuspid because the material had been felt by the patient as it

reached the apex. Two weeks later the tooth was extracted, though comfortable, for orthodontic purposes. Its well-opened canal was empty for a quarter of an inch at the apex.

To remove pins from roots a bibevelled Kerr broach may be driven into the cement or dentin about it and the drifts united. The pin may often be forced to one side and then jigged loose. If there be sufficient pin extending above the face of the root a "pin puller" may be used. If the pin cannot be loosened it must be drilled out bodily. A sharp round bur should be used to countersink the end of the pin, and then by the aid of oil it is cut into shavings. Frequent desiccation and examination to observe the presence of a metal remnant is necessary to avoid the accident of perforation.

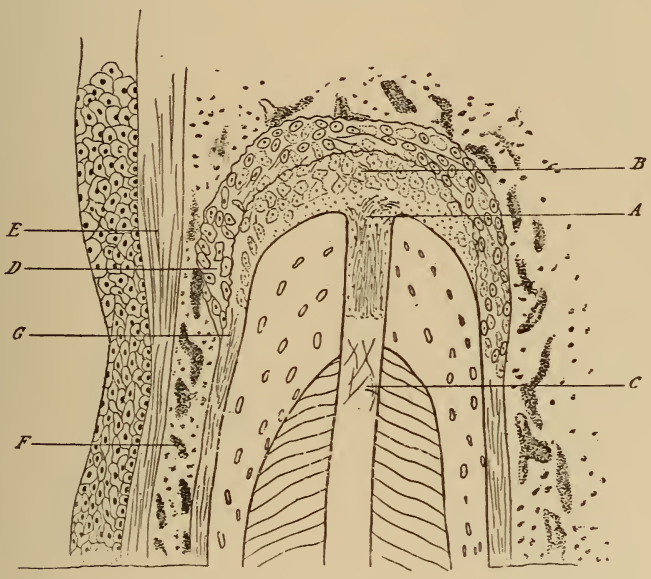
DENTO-ALVEOLAR ABSCESS

The term dento-alveolar abscess is a comprehensive one, meant to include all those cases of abscess having a beginning in the pericementum of a tooth and extending into the alveolar process or maxillary bone, and which have their origin in septic matter located in or introduced by way of the root canal of a tooth. It includes the anatomically specialized abscesses of such origin, *e. g.*, apical abscess, beginning at the apex of the tooth, or lateral abscess, beginning in a perforation. The description of the pathology of apical abscess serves for the other. It may be, but should not be, made to include pericemental abscess due to pyorrhea alveolaris. (See Chapter XV.)

Causes.—An apical abscess is a septic and suppurative pericementitis beginning in the pericementum at the apex of a tooth (the apical tissue). The pyogenic organisms, the Diplococcus pneumoniæ, the Staphylococcus pyogenes aureus and albus, and the Streptococcus pyogenes are the probable causes of the infection, as examination has shown (Schrier). These may exist in a gangrenous pulp, be introduced upon instruments uncleansed from a previous infection, or contaminated by contact with saliva or unclean hands at the time of operation, or the infection may have crept in by way of leaks in cavity or canal fillings. In apparently sound teeth the infection either enters by way of cracks or open tubules at the necks of teeth or beneath such cracks or in a pyorrhetic case through the apical foramen by way of the epithelial debris of the sheath of Hertwig constituting the resting cells of the peridental membrane. Entrance by way of the blood is a more remote possibility. Whatever be the avenue of entrance, infection occurs and produces the phenomena of suppurative inflammation (Fig. 498). There is arterial hyperemia followed by a venous hyperemia due to a collection of leukocytes along the walls of the small veins; emigration of leukocytes and exudation of lymph into the perivascular tissue occurs. In the area of

acute and active inflammation stasis occurs. The exudate, leukocytes, and tissue cells are liquefied by the peptonizing action of the bacterial ferments into pus. Coincidently these processes produce much swelling, which causes the pushing of the tooth from its socket, which in turn causes its overocclusion with its antagonists, and the mechanical irritation from this becomes an added cause of irritation. The inflammatory process spreads out from the central focus of pus formation, there being around the pus a zone of active inflammation or stasis; about this one of a lesser degree of inflammation, also full of leukocytes; about this an area of arterial hyperemia or the first stage of inflammation, and around this normal tissue. These areas are not sharply defined, but merge into one another (Fig. 498, *A*, *D*, *E*, *F*).

FIG. 498



Showing the morbid anatomy of septic apical pericementitis (acute): *A*, pus; *B*, area of dying leukocytes; *C*, septic matter in root canal; *D*, excavation of process (osteomyelitis; area of lesser inflammation); *E*, swollen periosteum and gum, hyperemic or normal; *F*, alveolar bone in a state of hyperemia: *G*, pericementum at edge of necrosis.

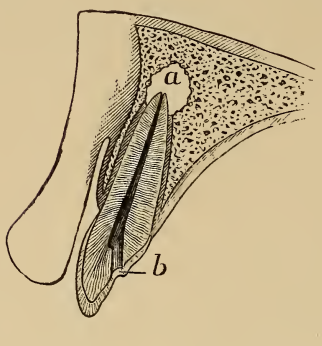
In this way the contiguous area of the alveolar bone and the soft tissues of the face become involved in the process, being discolored and tumefied in proportion to the extent of the pus formation and the inflammatory reaction thereto.

From a clinical viewpoint the abscess is incipient when inflammation of the apical tissue next to the foramen is profound and pus formation has just begun (Fig. 498).

The apical abscess is considered to be in the *first stage* while the pus is still in the apical tissue, in the *second stage* while the pus

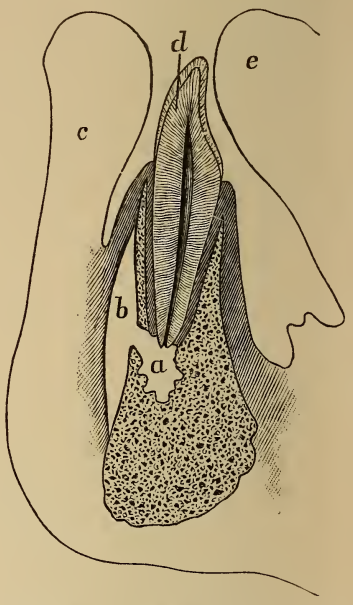
is involving the bone marrow in the alveolar bone (Fig. 499), in the *third stage* when the pus is in the soft tissues overlying the bone (Fig. 500), and as *chronic* when the pus has discharged, forming a fistulous

Fig. 499



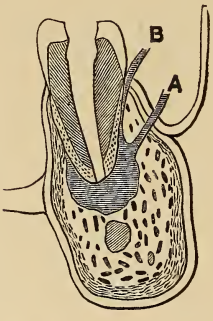
Acute abscess in second stage. Tooth opened at *b* for treatment, making a blind abscess. (Black.)

Fig. 500



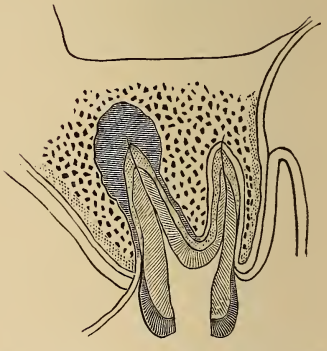
Acute aveolar abscess of a lower incisor in the third stage, with pus cavity between the bone and the periosteum: *a*, pus cavity in the bone; *b*, pus between the periosteum and bone; *c*, lip; *d*, tooth; *e*, tongue. (Black.)

Fig. 501



Abscess upon lower third molar, showing the usual paths of pus exit, *A* and *B*.

Fig. 502

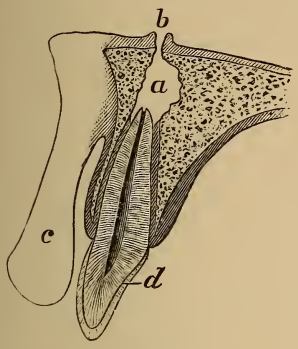


Abscess upon palatal root of an upper molar discharging at the neck of the tooth.

tract or sinus (Fig. 501), or has discharged *via* the canal (Fig. 499). These areas are the ones successively involved, and as the pus penetrates them the character of the involvement of the superjacent struc-

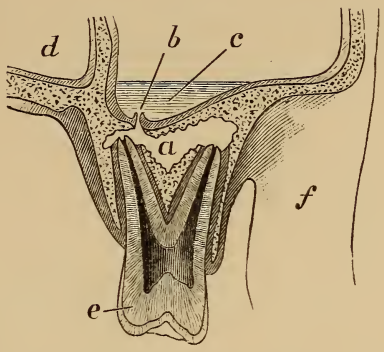
tures changes to the more severe form. Thus with pus formation incipient there is normal tissue at the gum surface (Fig. 498). With more advanced pus formation in the apical tissue the normal gum surface changes to hyperemic tissue, then inflamed tissue, then pus-containing

Fig. 503



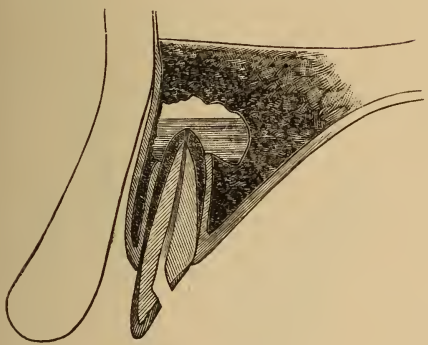
Dento-alveolar abscess at the root of a superior incisor, discharging into the nose: *a*, large abscess cavity in the bone; *b*, mouth of fistula on the floor of nostril; *c*, lip; *d*, tooth. (Black.)

Fig. 504



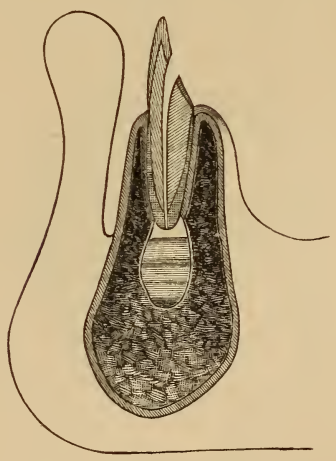
Dento-alveolar abscess at the root of an upper molar discharging into the antrum of Highmore: *a*, abscess cavity in the bone; *b*, mouth of fistula on the floor of the antrum; *c*, pus in the antral cavity. (Black.)

Fig. 505



Chronic abscess of upper incisor, showing tendency of pus to progressively destroy pericementum, owing to the influence of gravity.

Fig. 506



Chronic abscess upon lower tooth, showing tendency of pus to sink into the substance of the lower maxilla, owing to the influence of gravity.

tissue tumefied according to the amount and progress of the pus toward the surface (Fig. 500). The same theory applies to the swelling of the face.

While the abscess usually discharges through the alveolar plate and gum tissue either buccally or lingually (Figs. 501 and 507), it does not always

do so, but may discharge through the tissues of the face (Figs. 509 to 514), or into the antrum (Fig. 504), nasal cavity (Fig. 503), the floor of the mouth or pharynx (Fig. 513), or even dissect its way between the muscles of the neck and discharge at the clavicle.

Fig. 507



Chronic apical abscess discharging through the hard palate and threatening to discharge labially.

Fig. 508



Chronic abscess, showing denudation of apex of root (*a* to *b*), with deposits of calculi (*a*) upon cementum.

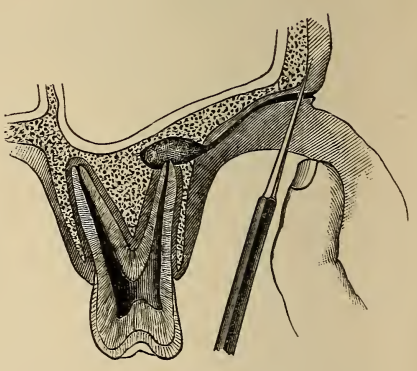
Sometimes it has a partial discharge by way of the root canal, either naturally or as the result of the abortion of it through the intentional opening of the root canal. Sometimes it dissects its way along the pericemental tract and discharges at the neck of the teeth (Figs. 501 and 502). An abscess on a root perforation near the gingival margin

Fig. 509



Scar caused by alveolar abscess discharging on the face. (Black.)

Fig. 510



Operation for the remedy of scar on the face caused by alveolar abscess. (Black.)

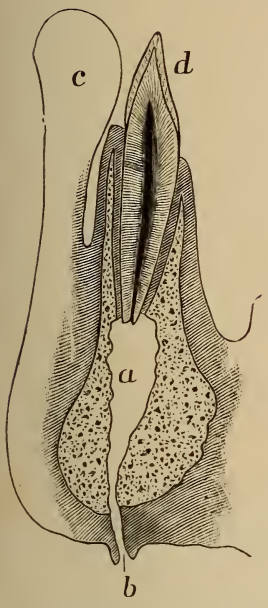
is very prone to do this, although it may discharge through the gum over the perforation. More than is often supposed the pus formation is subacute and the pyogenic bacteria inactive, so that the pus is semi-encysted in a fibrous enclosure or sac with organized and thickened

walls. The abscess may remain in this state for some time or develop an acute form (Fig. 515).

The adjoining teeth usually have more or less pericementitis, and the pulps may become hyperemic in consequence and be more responsive to thermal changes. In some cases the adjoining teeth are profoundly involved.

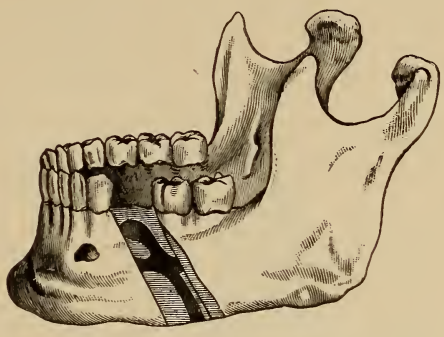
There is unquestionably a great difference in the severity of abscesses in different individuals, some having great tissue reaction and painful

FIG. 511



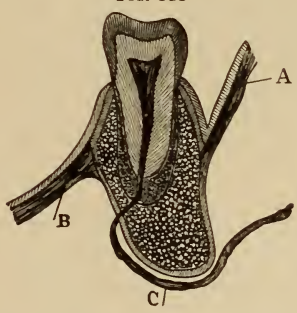
Chronic dento-alveolar abscess of the root of the lower incisor, with abscess cavity passing through the body of the bone and discharging on the skin beneath the chin: *a*, very large abscess cavity; *b*, mouth of the fistula. (Black.)

FIG. 512



Fistula passing down through the body of the lower maxilla. (Black.)

FIG. 513



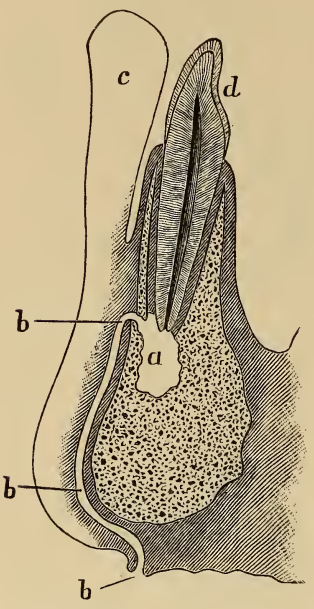
Abscess with tortuous sinus, opening upon the face: *A*, tissue of cheek; *B*, floor of mouth; *C*, abscess tract.

resistance to pus advance, or length of duration and wide involvement of the soft tissues, while others have an abscess reach to the formation of a fistula with little or no pain or facial swelling. The average time required is from twenty-four hours to three days. The anemic, cachectic, and strumous, as well as those having a syphilitic or tuberculous infection or history, are more liable to produce abscesses because of their general lessened resistance, and their pulps die more readily under conditions in which the pulps of others would live. In no case, however, can these conditions alone produce abscess. The exciting cause must be present.

When these predisposing conditions exist, however, and abscess supervenes, the relatively low resistance of the tissues may permit extensive destruction both as the result of the acute and chronic forms.

There are frequently manifestations of systemic intoxication from the toxins formed during the suppuration and absorbed from the inflammatory focus. Thus in ordinary acute cases there is some fever, often ushered in with a chill or chilliness. The pulse increases in volume and tension, is full, hard, and frequent. The tongue is coated, the breath fetid, the bowels constipated. The patient is weakened and made irritable by pain and the attendant loss of sleep and appetite. In the infection by Streptococcus pyogenes there is danger that these may change into the more profound symptoms of septicemia, *i. e.*, a soft, frequent pulse, repeated chills, diarrhea, clammy skin, general depression, and a disordered nervous system. Also in such an infection there is more cellulitis and less pus formation.

Fig. 514



Chronic dento-alveolar abscess at the root of a lower incisor, with a fistula discharging on the face under the chin: *a*, abscess cavity in the bone; *b*, *b*, *b*, fistula following in the periosteum down to the lower margin of the body of the bone and discharging on the skin. (Black.)

Diagnosis.—While the symptoms usually indicate a clear diagnosis, this is not always the case. A tooth may have a perfect color sometimes when examined by the transmitted rays of an electric mouth lamp; usually, however, it has at least an opaque appearance. Of two pulpless teeth surrounded by a zone of inflammation, the most tender is the one affected, although both may be involved at once.

Fig. 515



Small abscess upon roots of an upper molar.

A pericemental abscess due to pyorrhea alveolaris is located laterally, as a rule, and while it involves swelling of the gum, usually has not much facial involvement. Usually also it is connected with a pyorrhea pocket.

An abscess may be found in connection with a broken root or carious bone.

This is usually of the chronic variety in case of necrosed or carious bone, with one or more fistulæ leading to the diseased area.

A sinus usually leads from the occlusal direction to a broken root. If the gum has healed in this direction the abscess, if not acute, may be found with a sinus upon the side of the gum. An impacted tooth or odontome may have an abscess associated with it. If chronic the probe leads, as a rule, to enamel or the peculiar body. A cyst may be associated with a sinus.

An abscess sometimes forms beneath the flap of gum overlying a third molar. This begins as an ulceration of the under side of the flap, but the pus burrows between the tooth and the gum, and when well confined may develop laterally, causing the formation and at least partial retention of a quantity of pus in the tissues of the cheek. This condition more nearly simulates the lateral abscess associated with a pyorrhea pocket, and as by extension it sometimes involves the tonsil the case may be mistaken for an amygdalitis.

The direction pus may take is often determined by gravity, but the resistance of certain tissues may cause the pus to seek the easiest path. Thus, by discharging into the antrum it goes rather counter to gravity. In such cases as discharge into the antrum there is liable to be a collection of pus in that cavity which may cause destruction of the mucous membrane and bone. This condition is known as empyema of the antrum. The sudden subsidence of an acute abscess upon a tooth located beneath the antrum should create a suspicion of discharge into that sinus. If a fine probe can be passed an unusual length into a root canal it indicates this form of sinus involvement.

Upon a sound tooth the evidences of pulp vitality or death should be observed, *i. e.*, the pink translucency or the opacity to light transmitted by an electric mouth mirror, or the thermal tests of great heat or cold applied.

If the tooth be filled, or the dentin uncovered at any point, the interrupted electric current or the galvanic current, with the anode applied to the tooth, the cathode at the hand, produces a slight shock. In case of exposed dentin, dryness may interfere with the test. When a sinus is present a soft silver probe may often be passed toward the tooth affected.

As a rule, a sinus lies distally to the affected tooth. Taken in conjunction with the symptoms, the history, appearance, or reactions to tests afford a certain diagnosis. If a tooth be opened upon suspicion, evidence of vital dentin (sensitivity) should be carefully observed, as the drill is made to penetrate it. A timid patient will often unintentionally confuse pericemental tenderness with the pain of sensitive dentin.

In very doubtful cases, as when molars have deep amalgam fillings, or pins have been placed in root canals, or gold crowns cover the natural

crown, one should obtain a radiograph or else perforate the filling or crowns carefully and observe the conditions of sensitivity, odor, etc. In teeth filled having a history of canal fillings it is wise to suspect an imperfect or unattempted root filling.

Prognosis.—In a vast majority of cases the prognosis is good if the patient submit to the necessary therapeutics. If these can be thoroughly applied and regeneration of tissue induced the case may be considered cured.

Treatment.—In the initial inflammation and first stage of pus formation in an acute abscess the treatment should be abortive.

This consists of opening the pulp canals by removing any obstructions to its connection with the surface of the enamel, whether this be enamel, a filling, a root canal filling, etc. The one possible exception is a fixed and irremovable crown.

This must often be done under counterpressure, as the pericementum will be responsive to pressure. A thread knotted about the neck of the tooth may be gently pulled by the patient as the operator drills, or a bit of modelling compound may be moulded over the opposite surfaces of several teeth, chilled, and held by the finger of the operator. Holding a tooth with the finger and thumb or pressing a tooth firmly in one direction will often sufficiently steady it against the drill pressure or shaking.

The point of access may be through the dentin of a cavity, by partial or total removal of a filling and dentin perforation; by perforation of the enamel and dentin, or in unusual cases, where no better can be done, by perforation of the cementum and dentin at the neck of the tooth.

The manner of drilling is described on page 411. When the opening is made the canal should be washed with an antiseptic, while a barbed cleanser is gently passed to and fro until all debris is removed, and if possible the apical foramen cleared so that gases and pus may be discharged *via* the canal. The presence of blood in the canal is evidence of a complete discharge of the abscess contents. This usually gives prompt relief after a possible preliminary throbbing. The writer finds it best to leave the tooth open in the severe acute cases.

In order to lessen the irritation of occlusion upon the affected tooth a "guard" made of rubber dam should be applied to a slightly distant tooth. This consists of a strip of rubber dam about two inches long and as wide as the distance from the lingual to the buccal cervix over the occlusal face of the selected tooth. This is then folded into a pad the width of the occlusal face. A needle threaded with floss silk is then passed down through the right proximal corner, back through the right distal corner, down through the left distal corner, and back through the left proximal corner. This leaves two loops, as shown in Fig. 516. These are passed between the teeth mesially and distally of the selected tooth; the free ends are pulled, drawing the lingual loop up to the tooth. The free ends are now made into a surgeon's knot. This is to be left

until the tenderness of the abscessed tooth has almost gone. Aconite and iodin, equal parts of the tincture, or dental tincture of aconite, should be painted upon the gums, a pad of cottonoid placed over it, and the patient cautioned not to swallow the saliva.

Cold antiphlogistics, such as lead water and laudanum or cataplasma kaolini, should be applied externally. No hot external applications should be used in abscess cases, as they may cause an external fistula to be formed.

The mouth is to be frequently washed with an antiseptic. In simple cases with prompt relief this is all that is necessary; in marked cases the reduction of the inflammatory engorgement should be attempted in addition.

Fig. 516



Rubber dam guard for use in pericementitis: *A*, roll of dam threaded; *B*, guard fitted over tooth; tooth eliminated to show the manner in which the silk encircles it.

Sweedish leeches may be applied to the gum, or a cut or two made in the gum over the apex of the tooth will allow free bloodletting and drainage of the excess of blood in the pericementum. A hot pediluvium and a saline cathartic conjoined are useful as counterirritant derivatives, and the latter is also depletive, reducing the volume of the blood. The hot pediluvium with mustard added and diaphoresis conjoined are also useful. Ten grains of Dover's powder in divided doses in hot lemonade are given, in part, while the pediluvium is being administered, and the patient is later well covered up in bed.

Quinine in doses of gr. vj is given as a febrifuge and to limit exudation, and tincture of aconite, two drops at first and one-half drop each half hour, is given until the volume, tension, and frequency of the pulse are reduced.

If syphilis be a complication in these cases, potassium iodid, in doses of 10 grains each three hours, is useful as an antagonist of its influence and as a nervous sedative. Unless Dover's powder is used, morphin sulfate in blondes and morphin bimeconate in brunettes, especially those with blue eyes, or any persons with known idiosyncrasies to morphin, should be administered in $\frac{1}{8}$ grain doses repeated each hour up to $\frac{3}{8}$ grains. When great suffering renders it necessary, a hypodermic may take its place. When used, a saline cathartic should be given the following morning.

The Second Stage of Acute Apical Abscess.—In this stage the pus is in the bone and the infection considered more virulent, *i. e.*, the germs are

especially active. The abortive treatment should first be tried, and if free venting of pus is obtained, relief is usually given. If not given the case continues to the third stage. If bearable, or the surgical method be impracticable, a dental capsicum plaster may be applied to the gum or a roasted half-raisin may be applied. Either causes an inflammation of the gum, which advances the tissue that much nearer suppuration. Thus, it prepares a readily invaded tissue and hastens pointing. The contrary effect has sometimes been produced, and is explained upon the ground that the increased amount of blood has increased the phagocytosis and destruction of bacteria or has stimulated a restoration of the circulation, possibly both. Morphin is a useful adjunct when the pain is severe. For the purpose of hastening suppuration, calx sulphurata, ½ grain each hour, is useful. It also sometimes hastens resolution. It is proper to denominate this the expectant treatment.

When tolerable or imperative, the surgical method of venting the abscess through an opening in the gum is valuable. The apical region is located as nearly as possible by measuring the length of the tooth with a probe passed into the canal and over which a small piece of rubber dam is slipped as a guide. This is laid over the crown and gum and a tiny drop of carbolic acid is placed just above the point of the probe. A vertical cut is made in the gum down to the bone and a broad spear drill is driven through it into the abscess tract. Whether this shall be done under ethyl chlorid refrigeration, cocainization, or short general anesthesia, the operator must determine.

A gradual perforation is useful in some cases. This method, designed by Black, consists in gradually escharing and scratching the gum tissue. Successive applications of just such carbolic acid as adheres to the point only of a sharply serrated plugger are made, followed by slight scratching only so that blood shall not be drawn. In this way the bone is ultimately reached.

A fresh drop of acid is applied, the periosteum scraped away slightly, and the drill then used.

A Rollins tubular knife (Fig. 517) has been used with success to remove a piece of gum, after which the drill or a fine trephine (Fig. 518) is used. Some acute pain may follow this operation, but usually lasts only a short time.

If antiseptics are used to syringe out the abscess cavity, it is better to use a mixture of six parts hammamelis (aqueous) and one part Listerin as a partial sedative. The use of hydrogen dioxid is often very painful, owing to the rapid reaction with the blood present; and as it sometimes also drives the infective material into remote parts without disinfecting it, its use in this connection is not without danger, and should be avoided.

If extraction be imperative during the second stage of pus formation, it may be performed and removes the exciting cause. The alveolar

apex should be sterilized, and if return of sepsis is feared, a tent of antiseptic gauze may be inserted for a day only, and should then be removed and the cavity resterilized. Then a clot is invited by curetting the part. Ordinarily the extraction and free bleeding cures the case.

If secondary swelling occur, it is easy to remove the clot and then treat as above. The consensus of opinion of the best informed of the profession is that this procedure is correct.

The Third Stage of Acute Apical Abscess.—In this stage the pus has found its way through or beneath the periosteum on the outside of the bone; therefore, its germs are engaged in liquefying the gum tissue or in unusual location the mucosa or muscular tissue of the part. Except in these cases the gum is tumefied, a hard, circumscribed, inflamed nodule indicating pus near the bone, a soft, more generally diffused swelling indicating more superficially located pus, while a soft yellow or yellowish-

Fig. 517



Tubular knives.

Fig. 518



Walker-Younger trephines.

Fig. 519



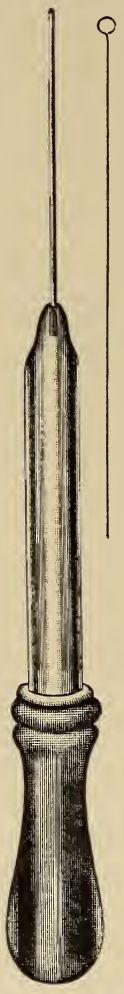
Rubber cap used as a vacuum cup.

pink tumefaction indicates pointing. In all these cases the indication is for a surgical opening of the gum rather than the opening of the tooth. The part should be gently disinfected with hydrogen dioxid on a ball of cotton, and a sharp bistoury should be boldly driven to the bone, with the cutting edge turned toward the occlusal. The lip or cheek is to be drawn well away to avoid injuring the coronoid, buccal, or facial artery. A cut about three-quarters of an inch in length is rapidly made by sweeping the edge and point downward occlusally. Too deep lancing upon the hard palate may injure the posterior palatine artery.

As this is usually painful, it is better to refrigerate the gum or operate under short general anesthesia, *e. g.*, nitrous oxid or the first impression of ether. Cocain is only useful in the case of deep-seated pus. Next, the abscess tract is to be gently washed out with a diluted hammamelis solution, preferably warmed. This may be done with the abscess syringe (Fig. 521).

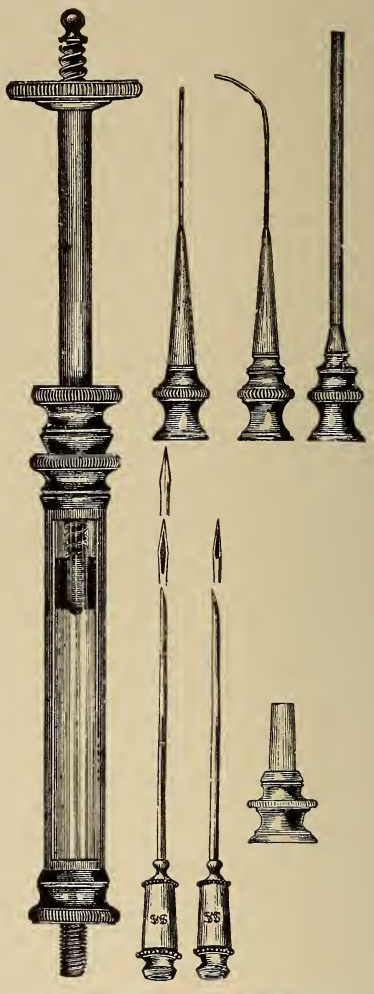
If the abscess has been deep-seated it is well to introduce a fine tent of antiseptic gauze through the opening into the abscess tract to prevent the too rapid healing of the external orifice which is apt to occur, owing to the approximation of the lips of the wound produced by cheek pressure. This healing permits a second collection of pus. The tent

Fig. 520



Minim syringe.

Fig. 521



J. N. Farrar's alveolar-abscess syringe.

should be removed not later than the next day, the abscess tract disinfected again, possibly with a mercuric chlorid solution, and the tent replaced. At this time the tooth should be opened and disinfected if not tolerable at the first sitting. When this is tolerable the crown should be tapped and formocresol sealed in the pulp chamber just before the operation of lancing, in order to permit disinfection, and thus limit

pus formation and to save time. Tents in alveoli should never be left a long time, as they become septic and may cause necrotic conditions of the alveolus.

The patient should always be cautioned to remove the tent if swelling return, as this indicates a stoppage of the vent with collection of pus.

When diffuse cellulitis with marked febrile disturbance passing into the adynamic type is produced, one should fear the infection with Streptococcus pyogenes and treat not only locally, but use blood germicides against a possible septicemia. In these cases there is little pus formed compared with the area involved.

The following is especially useful as a systemic antiseptic stimulant:

℞—Hydrargyri bichloridi gr. j
Tincturæ ferri chloridi f℥j—M.
Sig.—Twenty drops in water four times a day.

If the adynamia and other symptoms be progressive, medical coöperation should be obtained to divide the responsibility and to afford every means possible toward the cure. The extraction of the tooth followed by sterilization and curettement of the part, and the use of streptococcus antitoxin conjoined with the sustention of the vital powers by nutritious predigested food and alcohol is logical. In even ordinarily severe cases not of this variety there will be some fever due to the toxin absorbed, and the pain, and loss of sleep and appetite will cause physical debility.

For this there is nothing better than the following, as tonic, antiseptic, and antipyretic:

℞—Saloli,
Quininæ sulphatis (vel hydrochloratis) āā gr. lx
M. et fiant capsulæ no. xx.
Sig.—Take one four to six times daily, before meals when near them.

℞—Quininæ sulphatis gr. xxx
Acetanilidi gr. xxiv
Caffeiniæ citratis gr. iij
M. et fiant pil. no. xij.
Sig.—One every hour. (Endelmann.)

The facial swelling resolves with the cure of the abscess or its proper venting, but may be assisted by cold applications or cataplasma kaolini to the outside of the face and by gentle massage by the patient or nurse. Indurated swelling may be assisted in reduction by the operator through vibratory massage.

A piece of metal drilled through one end and mounted on a No. 303 mandrel may be revolved while the engine handpiece is strapped to or held in the hand.[1] This imparts a vibratory motion to the hand useful when the lubricated finger-tips are pressed over the face or gums.

The heat of a large electric lamp concentrated upon the face from a short distance, and followed by massage, is also useful in facial swellings due to cellulitis.

[1] W. H. Mitchell, Dental Brief, 1908, Academy of Stomatology.

After the reduction of acute inflammatory symptoms the treatment is the same as in the forms of moist gangrene (which see). The canals are sterilized by formocresol for a time, then opened, dressed with antiseptics, and when the abscess is cured the canal is to be filled.

Treatment of Chronic Apical Abscess.—As stated in the pathology, chronic apical abscess appears in three forms:

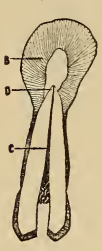
1. With point of discharge through the root canal.
2. With point of discharge through a sinus or fistula in the bone and gum or other soft tissue.
3. Without point of discharge as a latent focus of pus formation within the bone or apical tissue (an encystment of the pus) (Fig. 515).

1. In the first form the abscess sac consists of the apical tissue which has undergone more or less organization into fibrous tissue surrounding the cavity of the abscess, the lining of which continually undergoes solution into pus, which escapes *via* the open canal (Fig. 522).

This is usually the sequence of the abortive treatment of acute apical abscess or of an open canal produced by caries.

In the first variety the abscess cavity is usually of a size dependent upon the size of the acute abscess cavity and gradually grows smaller as the tissue organizes. In the second the abscess cavity may grow gradually larger as food packs into the cavity of decay and produces stoppage or semistoppage of the canal vent (Figs. 505, 506, and 508). According to the condition found by instrumentation or *x*-rays, or inferred by subsequent symptoms, the grades to be treated may be classed as:

FIG. 522



Chronic apical abscess, third grade: *B*, abscess sac containing a central pus cavity; *D*, apex of root; *C*, canal containing pus.

(*a*) Those in which acute abscess aborted has resulted in pus cavity closure to a point of almost obliteration.

(*b*) Those in which a small sac containing a fair lumen is found.

(*c*) Those in which a large fibrous sac exists and which is sometimes from one-fourth to three-fourths of an inch in length, with a corresponding lumen (Fig. 522).

(*d*) Those in which the pus sac and bone is liquefied and the bone is more or less necrotic (Fig. 508).

Gentle probing will usually give a guide to the extent of the abscess. The treatment for the first three grades consists of obtaining free access to and drainage of the abscess tract. This should be done with formalin, 5 per cent. aqueous to full strength formocresol, in the canal to sterilize what infective material exists, and prevent extraneous infection. The sealing in of formocresol should now be done as in moist gangrene.

If the infective material be not killed out there will be pus found in the canal. This should be removed after twenty-four or forty-eight

hours, and a new dressing applied. If after the first application no pus be found and no acute abscess be lighted up, the cotton dressing is more tightly introduced after appropriate canal enlargement if more be needed.

Each dressing should be examined for pus and a dry cotton introduced to take up any if a flow of it follow the removal of the dressing. Hydrogen dioxid should not be forced into such an abscess, as great pain may result from the reaction with the pus and blood.

When a tight cotton dressing has been in place a week and the canal dressing exhibits no odor of putrescence nor flow of pus, the root canal may be filled at least at the apex. In the third grade (*c*) an acute abscess is liable to be set up, although under formalin influence it may heal.

In a relatively few cases teeth cannot be closed at all without a recurrence of trouble within a short period, which trouble is usually relieved by opening the tooth. The repetition of this is annoying, and in some cases is due to the strength of medicaments, such as formaldehyd, which should be modified or abandoned for sedative antiseptics, such as phenol-camphor or eugenol plus menthol. In some of the cases the gases may accumulate more rapidly than disinfection occurs. In other cases the irritability of the tissues seems to produce intolerance of any remedial measures. What is known as "systematic stopping and unstopping" seems sometimes to overcome the irritability and accustom the tissues to being covered. The system consists of stopping with eugenol and menthol or modified formocresol for about eight hours, or from morning to afternoon, then venting and redressing until the following morning, then for twenty-four hours, then forty-eight, then seventy-two, etc., until the tooth stays stopped.

There have been a few patients who cannot seem to have teeth "treated," nearly all cases being practical failures even when aseptic. Some few may be kept in comfort for a while with permanent vents, but this is objectionable. The making of an artificial fistula should be attempted. In some cases the writer has found an error of diagnosis on his part in that apparent apical irritability has been due to a fine filament of ulcerated pulp in the extreme apical end of the canal. This having been punctured full of carbolic acid and removed, the case has proceeded to a cure.

The fourth grade (*d*) is almost certain to cause reaction. In either case an external opening should then be made, establishing a fistula. If these grades can be diagnosticated beforehand, it is well to do this before canal treatment.

2. Cases which have an established fistula are usually easy of treatment mechanically.

In all cases the organized tissue lining the abscess tract is breaking down into pus and continually regenerating itself except in a fair number

of cases in which the abscess cavity enlarges at the expense of the organizing tissue. This latter result is usually due to gravity, which confines the pus germs in crypts of the abscess walls.

The canals should be made continuous with the abscess cavity. This is not always easy in molars, and, as a rule, canals which have sensitive tissues at their ends should not have this tissue lacerated.

Instead, in molars, after due and moderate cleansing of canals an application of formocresol for twenty-four hours before thorough canal manipulation is wise. They are then freely opened and formocresol dressings placed in them. If the fistula does not show signs of healing in a week it should be washed out with antiseptics and the canal which did not have sensitivity at its end should be filled with a thread of cotton saturated with carbolic acid or phenolsulphonic acid,[1] and pressure made upon it with raw vulcanite to force it through the foramen and into the abscess tract. A bit of cottonoid should be placed over the fistula to prevent the escharing of the mucosa. The pus-forming area is thus eschared, killing the invading bacteria and stimulating the tissue to regeneration.

The canal is again dressed with formocresol and a week or more allowed.

Hydrogen dioxid should be avoided in this connection, as it has forced the infective material into distant parts of the abscess tract without disinfecting it.

The medicament may be drawn rather than forced through by the use of an unperforated rubber cup pressed upon the wet gum and then released. It acts as a vacuum cup (Fig. 522, *a*). This rubber cup may be mounted upon a tube having a shoulder filed on it and the tube be attached to the saliva ejector or a rubber bulb.

If pus formation persist, and especially if the pus be found on the end of the dressing, or the foramen be widely open, the pus either flows into the canal and becomes a continuous cause of infection; or the cotton goes through the root end and acts as an irritant. In either case the filling of the canal is indicated. This forces all pus to remain external to the canal. The fistula should now be irrigated with sulphuric acid, 25 per cent., to dissolve any calculi present, kill bacteria in the abscess crypts or cemental lacunæ, and stimulate the tissue (Fig. 508). Care is to be used not to eschar the oral tissues or affect the clothing of the patient. A minim syringe limits the amount used and a pad of cottonoid catches any excess if this be not used (Fig. 520). If this fail after weekly attention for a month or more, there is probably dead bone or a dead and infected root end, and root amputa-

[1] Acid phenolsulphonic consists of 97 parts, by weight, of concentrated sulfuric acid and 93 parts, by weight, of phenol, kept at 100° C. for about twenty-four hours to produce a reaction, when sufficient distilled water is added to make the liquid assay about 80 per cent. of phenolsulphonic acid. (Buckley Lilly.)

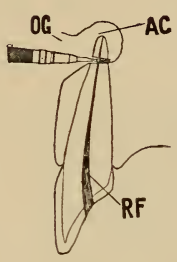
tion is in order. There is an exception to this rule in some cases. The writer has had these fistulæ heal up when let alone for a time, and if no signs of active pus formation are present this may be resorted to.

In other cases the gravity of the pus alone has prevented healing, and when the patient has been instructed in the use of a Sub. Q syringe and antiseptic solution several times a day, the abscess has healed. The theory is that the constant removal of the pus has given the granulations opportunity to spring up.

The use of the rubber cup (Fig. 519) as a vacuum cup draws pus from apical abscesses and stimulates a flow of fresh blood in the area. This blood is said to have a higher opsonic index than normal blood, and hence greater phagocytic effect. It acts to massage the gum and may be applied by the patient. A small glass cup or rubber cup with rubber bulb attached may be used for the purpose. (See previous description.)

The amputation of root apices, while not always productive of the desired healing, at least benefits the case.

Fig. 523



Amputation of root apex: *OG*, opening in the gum made by packing fistula; *AC*, abscess cavity; *RF*, root filling.

A radiograph is a useful guide to the position of root apices, and especially of the root causing the abscess if not known (Fig. 515). When located, the fistula should be lanced open and the orifice in the bone enlarged, if necessary.

The abscess cavity is then packed with gauze until the root apex is visible; it is then removed by means of a dentate fissure bur laid against its side. The canal must previously have been solidly filled with gutta-percha or oxychlorid of zinc. The root should be trimmed down with burs to a point below the healthy bone level. All necrotic bone is to be removed (Fig. 523).

A variant of this operation was introduced by M. Schamberg. It consists, after root location by instrumentation or radiograph, of entering the diseased area with a surgical bur and cutting away the root. This is the simpler technique, if one be sure of his position.

For a short time this cavity may be packed with gauze, or a clot may be invited, the mouth and parts kept sterile, and the case watched. If necessary, stimulation of the tissue by silver nitrate or scarification should be employed.

The part heals by granulation and new bone is generated.

When the fistula is upon a perforation near the root apex, or a much lacerated foramen, the canal may be filled with oxychlorid of zinc, which is allowed to go through the opening into the fistula. The excess of this is removed after partial hardening of the material. In fistulæ

located upon low lateral perforations, either oxychlorid of zinc or oxyphosphate of copper are worked through and allowed to set. The excess in the fistula is then removed.

If in any case this does not heal, the fistula is to be packed open with gauze and a retention cavity made in the root side if accessible. This is filled with a tight amalgam, compressed air being used to keep the part dry. If impossible to keep dry, the cavity is touched with silver nitrate and the filling well compressed under a stream of water.

Time for healing may be required in some of these cases. If these latter cases will not heal, or the filling methods are not successful or possible, extraction and replantation is the last resort, if the tooth be valuable.

FIG. 524



A skiagraph of apical abscess cavity about two root apices; incurable by ordinary means.

FIG. 525



The same after root amputation.

FIG. 526



The same thirty days later, showing a certain amount of new bone formation. (Price.)

An impression is taken with the tooth in place, and a splint is constructed over the model, the occlusion being considered. The tooth is extracted, the abscess tract curetted, and the alveolus packed with antiseptic gauze or cotton tampon saturated with 50 per cent. phenol-sodique.

The tooth apex is slightly cut off, the canal opened from the apex, and the tooth dropped into a germicidal solution, as lysol, 5 per cent., or 50 per cent. phenol-sodique.

After a time it is dried, the canal filled with gutta-percha, the perforation filled, and the tooth returned to the solution.

The tampon is removed, the socket again syringed out, when the tooth is returned to place, the part dried, and the retaining device cemented in place. This should remain in place for about eight weeks, to allow reunion or ankylosis to occur.

If the parts be badly infected, it may be well to allow a few days to elapse between the extraction and the replantation. In the interim the tooth may be prepared. If the tooth is to be replanted in a new

position the tooth must be cut from the plaster model, a hole drilled in the base of the model and the tooth put in its proper relation. The splint is then constructed. At the time of replantation the socket may be freed of clot and any granulation by the use of a bone reamer gently applied. In some cases the transplantation of another tooth or root with an artificial crown upon it may be done instead of replanting the tooth. (See chapter on Plantation.)

Fistulæ upon the Face.—If a fistula be formed upon the face it will usually heal if the root canal can be made continuous with the abscess tract and no necrotic bone be present other than that usually formed by a chronic abscess. This done, the treatment is the same by means of formocresol sealed in. If pus ceases to form, the apex of the reamed canal may be filled with gutta-percha made antiseptic with aristol or iodoform, formocresol placed in the remaining open canal, the tap sealed, and time allowed for healing. If it will not heal, amputation and bone curettement may be done from within the mouth. Still failing, extraction is the final resort. These fistulæ heal with least scar if the tooth be not extracted (Fig. 509).

If cicatricial tissue form within the cheek tissue it may bind the cheek tissues to the bone in such a way as to cause a depression of the facial scar. To remedy this a cut should be made in the tough fibrous cicatricial cord from within the mouth, while the cheek is drawn outward. A pin is to be passed through the depressed portion of the facial cicatrix and a small compress of gauze laid under each end (Black). This raises the centre of the cicatrix, separates the cut ends of the cord, and permits a new growth of tissue to reunite it into a cord of greater length, which causes less binding (Fig. 510).

Fistula in the Antrum of Highmore.—In recent cases this may consist of a simple fistula discharging pus into the antrum. The diagnosis can only be made inferentially when an acute abscess in the region has suddenly subsided, and actually by pressing a fine probe or forcing a stream of antiseptic fluid through the root canal into the antrum, or by skiagraphy. If treated like any other fistula by way of the canal, it should heal, and some cases seem to have done so. In long-continued cases, with general septic inflammation of the antral mucosa and offensive discharge into the nasal cavity, the antrum must be opened. The mucous membrane of the patient is anesthetized and an opening made through the lower buccal wall of the antrum large enough to permit of satisfactory examination. After sterilization of the antral cavity, all necrotic bone should be removed, and the antral cavity irrigated with antiseptics and packed for a period with a long strip of antiseptic gauze fed directly from a wide mouthed bottle in which it has been kept. Later it may be irrigated for stimulation, with Lugol's solution (liquor iodi compositus, gtt. xx to the ounce), or upon occasion even with pure tincture of iodin or an alcoholic

dilution of it. The root canals should preferably have been previously sterilized and filled. If necessary the root apex affected may be amputated at the time of operation. After healing of the antrum, if the opening does not heal, a slight plastic operation upon the mucous membrane will usually close it (Fig. 504).

In all irrigations of the antrum the head should be inclined forward over a basin to allow the solution to run out of the nasal cavity. In using iodin it is well to pack the nostril on the affected side with cotton, removing it after the irrigation.

In cases in which the pus finds its way along the root of the tooth and discharges at the gum margin, there is liable to be more or less calculus deposited upon the root surface, causing it to simulate a case of pyorrhea alveolaris. The calculus may exist also at the apex in some old cases of chronic apical abscess with the ordinary form of fistula. This calculus should be removed with pyorrhea instruments or by injection of 10 to 25 per cent. sulfuric acid. Otherwise the cases do not differ from the ordinary.

Systemic Complications.—The cachectic, debilitated, anemic, tuberculous, and syphilitic are liable to extensive pus formation, which enlarges the cavity unduly and may involve the roots of other teeth or even cause devitalization of their pulps, which aids in the continuance of the abscess by adding a fresh cause.

In such cases all the dead pulps should be removed after careful diagnosis, and the patient should be instructed in the use of a Sub. Q syringe and a mild antiseptic, the object being to keep the dependent parts free of pus and allow granulations to form rather than be constantly broken down.

In addition, such systemic medication or remedial measures as will raise the recuperative and resistant powers of the tissues should be employed.

If very persistent, a vaccine may be employed, after the method of Wright, to raise the opsonic index. (See chapter on Pyorrhea Alveolaris.)

The direct results of infection toxemic and septicemic, have already been considered (see p. 445).

3. In the third class of cases the diagnosis is either made because of a latent swelling on a filled tooth or cyst of fluid contents overlying a root apex, or because of subacute apical irritation, which either opening the tooth demonstrates to be due to septic causes, or a radiograph shows to be an abscess cavity. The presence of eruptions upon the body not otherwise accounted for or other evidence of toxemia should cause these latent abscesses to be sought as the source of toxic effects. In the case of a cyst a fistula should be established; in the other the canals should be opened and the tooth treated as for the first or second grade of abscess discharging *via* the canal.

Necrosis and Caries of Bone.—In some cases the inflammatory reaction is so severe that some of the bone may be involved *en masse*.

This is fortunately unusual, the usual result being a liquefaction of both soft and hard tissues. If it occur as a sequestrum, this gradually loosens, and either appears at the fistula as one or more pieces, or, being found loose, by instrumentation is worked out, the fistula being enlarged if necessary. If the thorough loosening of the pieces is awaited, the patient should syringe out the abscess tract with antiseptics, and the operator should see the case frequently until the operative procedure is necessary. The general health is to be improved if necessary.

Ulceration of an alveolus may result from the extraction of a tooth, and if neglected may produce necrosis of the bone. In both cases the pain is severe and often reflex. The condition has been termed "dry socket."

If ulcerated, the alveolus is painful to touch; if necrotic, the superficial bone is insensitive, the ulceration being more deeply seated in the diploëic structure.

The best and most radical treatment consists in antisepsis followed by the administration of short general anesthesia, or, if necessary, cocainization of the gum and a thorough removal of the superficial ulcerated or necrotic bone to a point capable of healthy granulation. After injection, a clot is invited to fill the alveolus in order to stimulate the condition following an ordinary extraction.

As an alternative, the ulcerated cases may be thoroughly saturated with full strength trichloracetic acid solution, which acts as a stimulant, escharotic, and germicide, and a paste made from orthoform, zinc oxid, and vaseline may be packed into the alveolus.[1] The patient should be seen not later than twenty-four hours afterward, and the application repeated, or, better, a clot invited after further sterilization.

Hydrogen dioxid with mercuric chlorid added (1 to 1000) and applied topically is effective as a germicide. In caries of the bone a progressive absorption of the cancellated bone and subsequent suppuration of its marrow results in a honeycombed mass of dead bone which tends to become gradually large. It should be removed and regeneration invited.

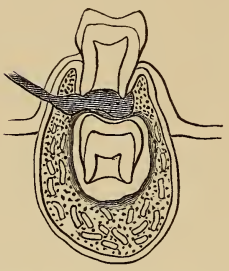
Abscesses on the Temporary Teeth.—The treatment of abscess in case of temporary teeth being effected, does not differ in principle from that in the permanent teeth. The only complication is the state of the root end, whether partially absorbed or not. A plastic root filling is indicated, the conditions being met by paraffin or wax combined with aristol or paraform. (See Root Canal Filling.) If the roots are almost all resorbed, extraction is often better than canal treatment (Fig. 527).

Suppuration following Extraction.—When the suppurative process is active, whether in the second or third stage or when a fistula exists,

[1] Jack, International Dental Journal, 1905.

the surrounding tissue is sometimes involved to such an extent that whether the tooth be extracted or not the process may continue. It has happened that adjoining teeth have been involved or that the infection may travel along the periosteum and cause profound and widespread infection. In a case of a boy aged 14 years, at present under treatment, a right lower molar was the starting point from which the infection spread along the bone, so that every lower tooth from the right second molar to the left second molar was profoundly loosened, the gum detached, and the chin tissues swollen. Pressure upon them caused a copious flow of ichorous pus from a number of fistulæ and gum margins. The patient suffered from aneurysm due to the aseptic intoxication. The case referred to the writer was sent to a surgeon, who made a lineal incision beneath the rim of the jaw, and after irrigation packed with antiseptic gauze. The case is progressing satisfactorily, with some hope of saving a fair number of the teeth, which are becoming more firm.

Fig. 527



Showing the relations of an abscess upon a temporary tooth, with the crown of a developing permanent tooth underlying it.

Such cases illustrate the dangers of apical infection and the necessity for supervision after treatment or extraction in all cases of abscess. The removal of the primary exciting cause and active sterilization of the parts is indicated. Systemic treatment should be conjoined.

Non-septic Pericementitis.—This form of inflammation of the pericementum is non-infective, and is due to some form of violence or chemical irritation of the pericementum or is the result of a violent pulp reaction by reason of which some of the excess of blood in the pulp finds its way into the apical tissue.

In all cases there is an overfulness of blood in the apical tissue associated with swelling, which causes the tooth to be somewhat extruded, therefore it maloccludes, which adds more mechanical irritation.

In so far as canal treatment is concerned the cases may be divided into:

1. Those in which the violence has been or is of external character, the cause not continuing in action or being present only as malocclusion; sometimes as a wedge or regulating appliance. If the pulp be not hopelessly involved the treatment should consist of rest attained by means of guards to prevent occlusion and counterirritant applications upon the gum over the tooth in mild cases, distant in severe ones, or the use of depletion and sedation in severe cases. As an oral sedative, cold aqueous extract of hamamelis is very useful. Derivation should also be employed.

Traumatic pericementitis may cause a profound swelling of the pericementum and extrusion of the tooth which only replantation will cure.

2. Those in which by way of the canal the apical tissue has been lacerated by broaches or drills, irritated by pressure of air, canal fillings, etc., or chemically irritated by powerful chemical substances. Secondary hemorrhage after pressure anesthesia and pulp removal is a mechanical cause. In all cases such should be avoided, or, if present, removed, and sedatives, such as phenol-camphor or eugenol, to which menthol has been liberally added, should be placed in the canal on cotton. Counter-irritants are to be applied to the gum and, if necessary, guards applied to prevent occlusion.

When canal fillings have been carefully made they sometimes cause a limited non-septic apical pericementitis, which will often pass away under the action of counterirritants; therefore some judgment must be exercised as to the removal of such canal fillings.

Perforations and Resorptions.—The same accidents that occur in canal opening in the case of the removal of anesthetized or devitalized pulps may occur in all gangrenous cases with somewhat increased liability to infection of the pericemental tissue.

In old cases the pericemental tissue may hypertrophy, causing the condition of hyperplastic (fungoid) gum. This should be sterilized and then may be frozen with ethyl chlorid and ablated with sharp instruments, or it may be saturated with trichloracetic acid and ablated, or it may be pressed away (resorbed) with cotton saturated with tincture of iodin or an antiseptic oil. The perforation is then covered.

The Filling of Perforations.—Perforations made high up in the canal, after being appropriately sterilized with formocresol, should be filled with wax or with gutta-percha cones, which have been accurately fitted to the openings. It is often difficult to do this, but the effort should be made. When ready, a little antiseptic chloropercha is to be placed in the perforation or upon the cone, and the latter packed to place.

FIG. 528



Idiopathic resorption of permanent root. The bay upon the side exposed the pulp and perforated the root as shown. Crater-like resorption about apical foramen. Pulp first devitalized on account of persistent pain and the tooth later extracted.

In low perforations without a fistula associated, the opening of the perforation should be enlarged inwardly and a ball or plaque of aseptic, warm, low heat gutta-percha, or even temporary stopping, adapted to the opening. A piece of pure gold plate may be burnished over an accessible opening, and be adapted with thick chloropercha or temporary stopping. Any of these may be fixed in place with oxyphosphate of zinc. Quick-setting oxyphosphate of copper in its soft, gummy state may be painted over the tissue and root opening by means of an instrument,

or the perforation may often be satisfactorily closed with copper amalgam. When in posterior teeth a pin must be used, the pin may be made smaller than the root canal and be coated with wax, soft oxyphosphate of copper is put in the canal, and the pin gently thrust in. When the cement has set the pin may be heated and withdrawn, and when included in the intended superstructure, the pin may be again cemented in place.

When a perforation threatens to produce an abscess an artificial fistula should be made and the case treated as described on page 447.

If a perforation have a fistula associated with it, the oxyphosphate of copper may be allowed to go through the fistula, by way of which any excess may be removed.

In case of resorption of the roots of permanent teeth great difficulty may present, the soft, absorbent tissue having grown into the cavity in the root side which it has made. A radiograph will aid in determining the extent of the lesion, which usually renders canal treatment impossible and extraction imperative.

THE FILLING OF ROOT CANALS

In all cases in which the removal of the dental pulp from the canals is necessary, it is imperative that the pulp canals shall be filled with some substance that shall mechanically obliterate it by sealing it throughout its length in order to prevent the ingress of fluid either from the mouth or apical tissue. Such fluid is liable to putrefaction, and the results of putrefaction follow. If made antiseptic, it also tends to kill any bacteria which may find a partial entrance. The mechanical sealing may be defective, even when the best possible effort has been put forth to make it perfect, so that the addition of more or less permanent antiseptics is valuable.

It matters little whether a canal filling is hard or soft provided it is permanent, that the above conditions are fulfilled, and that it is not disturbed by any subsequent work.

It also makes very little difference whether the pulp has been removed while aseptic or has been in a septic state, provided the canal has been rendered sterile by appropriate means.

In other words, when the canal is aseptic and the apical tissues sterile and healthy, the canal is ready for filling. The length of time this may require also makes no difference The size of the apical foramen, the presence of inaccessible apical portions of canals, the presence of perforations and some other conditions, however, indicate a choice of some root filling rather than others, so that there is no absolute rule for all cases. The following root canal fillings are useful.

Gutta-percha.—This is usually the ordinary, low heat, pink gutta-percha base-plate containing vermilion and zinc oxid. Cones may be

rolled or left with flat sides. Prepared cones may be purchased which have an accurate taper and are either round- or flat-sided. The flat side permits any adjunct plastic filling material or solvent to flow down the side of the cone rather than be forced toward the apex.

Temporary stopping may be melted in a spoon and aristol added to it. It is then rolled into cones for use. Instead, a stick of it may be warmed at a point away from the end and then be pulled out into two cones, which may be further rolled out. They may be rolled in powdered aristol if desired.

Chloropercha.—This is a solution of gutta-percha base-plate in chloroform. Usually a quantity of aristol or iodoform is added to make it antiseptic. As it shrinks in hardening it should be used in conjunction with gutta-percha cones or carried upon cotton twist or floss silk, which it saturates, transforming them practically into a solid mass when the chloroform evaporates.

Eucolypto-percha (Eucapercha).—The basis of this substance is a solution of gutta-percha base-plate in eucalyptol. To this various antiseptics may be added. There are various modes of making this substance. B. L. Cochran[1] suggests the following:

℞—Gutta-percha base-plate ℥ss
Dissolve in chloroform q. s. to a thin solution. Add saturated solution of thymol in eucalyptol f℥ss
Let the chloroform evaporate.

Eucapercha Compound (Buckley Lilly) is a simple solution of base-plate in eucalyptol made by aid of heat.

Formopercha (Blair) has paraform and oil of cassia added.

This material may be warmed into a creamy paste and be used either on cotton or be used in conjunction with gutta-percha cones.

Zinc Oxychlorid.—This consists of the ordinary zinc oxychlorid cement, which consists of modified calcined zinc oxid for the powder and diluted zinc chlorid as the fluid.

It is antiseptic for a time at least, and may have iodoform incorporated with it if desired. It is carried to place on a thread of cotton, or may be used with gutta-percha cones. The addition of a trifle of glycerin retards setting.

A so-called embalming paste is prepared as follows:

℞—Paraform 1 part
Thymol 1 part
Glycerin 1 part
Zinc oxid 1 part or more

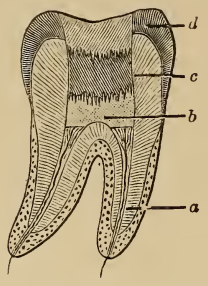
Or,

℞—Paraform 1 part
Thymol 2 parts
Alum 1 part
Zinc oxid 2 parts
Creosote to a thick or thin paste.

[1] Dental Review, 1905.

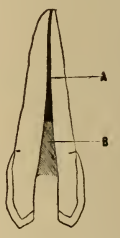
This is used as a temporary germicidal canal dressing on cotton or as a root filling with gutta-percha or temporary stopping cones which are pressed into it.

Fig. 529



a, root portion of pulp; *b*, mummifying paste; *c*, zinc phosphate; *d*, gold or amalgam.

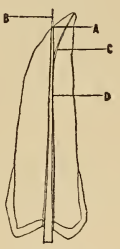
Fig. 530



Root-canal filling: *A*, gutta-percha; *B*, zinc oxychlorid.

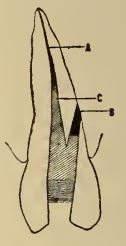
Wax or Paraffin.—Either of these may have a third of its bulk of salol, aristol, or iodoform, or a fifth of paraform added to it while melted in a spoon. It is then rolled into cones or small pellets. In use a pellet is dropped into the dried pulp chamber and a hot Evans root drier point applied. As it melts, the metal point is carried down into the root and the fluid material pumped to the apex. Capillarity does part of the work. It adjusts itself to the tissue and the canal walls. The pulp chamber is then cleared of excess wax, etc., and filled without pressure.

Fig. 531



A, perforation through side of apex; *D*, cone of gutta-percha passing through; *B*, portion to be cut off; *C*, portion of canal not treated.

Fig. 532



Lateral perforation due to holding a bur at a wrong angle to the axis of the root: *A*, root canal subsequently filled with gutta-percha; *B*, perforation filled with a fitted cone of gutta-percha; *C*, zinc oxychlorid.

Salol.—This is a solid antiseptic, melting at 104° F. It is used much as paraffin is. A gutta-percha cone may be thrust into it while fluid. It often seems to disappear from canals, and unless used with paraffin is to be used only as a temporary root filling.

Canada Balsam.—A solution of Canada balsam in chloroform to which hydronaphthol is added (Williams) makes a useful solution in which

to saturate cotton twists or to moisten canals previous to the introduction of a cone of gutta-percha.

Normal Tapering Well-opened Canals.—In these canals gutta-percha is admirable; a little eucalyptol is applied to the canal walls and a section of a suitable cone mounted by heat on the end of a canal plugger which will go to or nearly to the canal end is gently but firmly pressed into the apex of the canal. Temporary stopping cones are more readily adapted, and as they can be made antiseptic, are valuable.

The rest of the canal is then filled with other sections or with zinc oxychlorid made thin and carried to place on cotton twists. The latter may be used for the entire canal, and should then be preceded by a tiny bit of cotton saturated with an essential oil to prevent irritation of the apical tissue. It is claimed that this cotton is acted upon by the zinc chlorid being transformed into an amyloid condition.

A variant consists in moistening the canal with chloropercha or eucalypto-percha, and using the section of cone or pressing in an entire cone. A second cone may be placed at the side of the first and both compacted after warming with a hot air blast, or the first cone alone used.

Ottolengui advises the use of bits of floss silk an inch long to be saturated with chloropercha and dried. These are to be pressed into chloropercha previously placed in the canal and crimped to place. An end is left projecting into the pulp chamber. If necessary this may be caught and the dressing withdrawn.

Another variant is the use of chloropercha on cotton, which makes a very accurate and easily introduced root filling when carried to place on a properly formed and tempered Swiss broach or prepared Donaldson bristle.

When the broach must be bent to enter canals, loosen the broach first before introducing into the canal, thus leaving the cotton loosely mounted on the broach. To prepare a Donaldson bristle cut off the hook and flatten the end upon an Arkansas stone, then lay upon a glass slab and burnish thoroughly to remove any bur left. In use the cotton and broach are rolled with the left forefinger and thumb only. It is obvious that to do this the broach must be perfectly straight. The writer believes the prepared Swiss broach not only more facile but economical in use.

To prepare broaches, select accurately tapering Swiss or English broaches from which the temper has not been drawn. Next, draw the temper to a blue color by placing a few in a test-tube and heating first at the shank, gradually drawing the tube over the flame toward the points; let cool on any open surface. The point is left if canal exploration is intended. For carrying cotton twists, cut the end off with scissors. To wind the cotton lay a wisp on the left forefinger, lay the broach upon it, close down the thumb, then quickly revolve the broach with the

right forefinger and thumb, stroking the cotton with those of the left hand into a symmetrical cone. To use as a swab, rotate in the canal to the right. To leave the cotton in the canal, rotate to the right as the twist is pressed to the apex. Then turn the broach once or twice to the left to loosen it from the cotton, withdraw a little, then press in again. Thus the cotton is crimped upon itself.

Roots with Open Foramina.—These may be incomplete roots with very large apical openings, in which case wax with aristol is the best filling used, as previously stated. It should be said again, however, that if possible the pulps of such a tooth should be capped to permit root formation to be completed.

If the foramen is of moderate extent and either natural or unfortunately made with drills, gutta-percha cones are valuable. To determine the size of the cone, one of two methods may be employed. Perhaps the more accurate is the employment of a series of gradually increasing sizes of canal pluggers. One should be selected which will just fit the apex or be a trifle too large. By placing this in the hole of a draw plate, a specially rolled cone or even a slightly tapering size may be made to fit the hole in the plate. The canal is moistened with eucalyptol or chloropercha and a quarter-inch section of the cone is carried on the plugger to its place in the root canal apex. A slight protrusion is not ordinarily productive of injury. A cardboard perforated by the respective plugger will do instead of the draw-plate. If the root length was previously measured with a piece of rubber dam slipped over the plugger shank and some known point on the tooth used as a guide, the cone should be seen to go down until it chokes the foramen, when the dam should be above the guide point a distance equal to the length of the cone section used.

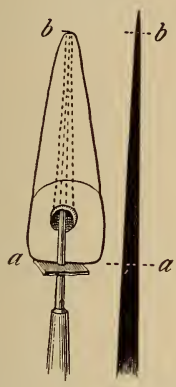
In the second method a long, tapering cone is prepared. Some point on this must fit the foramen. It is tried in and as often as sensation is felt it is cut off a trifle and tried again until it chokes the foramen without sensation.

In case of abscess, especially if filling is a means to a cure, this may extend beyond the apex of the tooth.

The cone should be marked at a point corresponding to the guide point chosen and laid aside. Next, a fine hook made by bending the tip of a fine broach to a right angle, then cutting it close to the shank, has a piece of rubber dam slipped over it and is passed through the apex and hooked upon the edge (Fig. 533). The dam is slipped to the chosen guide point. The probe hook is withdrawn, the dam laid at the mark on the cone, and the cone cut off at the lower edge of the hook (Fig. 533, *b*). In use, a little solvent, preferably chloropercha, is placed in the canal and the cone slowly slipped to place until the mark coincides with the guide point. The cone is then cut off with a hot instrument, warmed, and gently packed into the canal.

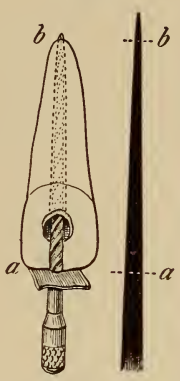
When the canal has been reamed with a small engine reamer, and the apex enlarged, the hook may be placed and have a bit of rubber dam on it as a guide. Then slip a bit of dam over a larger tapering root reamer at a corresponding length. Drive the reamer in until at the guide point. This gives a tapering cone shape to the canal and is a guide in the construction of the cone (Fig. 534).

Fig. 533



Manner of measuring the length of a root and fitting a gutta-percha cone.

Fig. 534



Manner of tapering a canal to fit a cone of the same size.

Canals with Inaccessible Apices.—Any tissue in such apices should have been mummified or sterilized with formocresol or be treated by Rhein's method[1] of filling a canal with mercuric chlorid in hydrogen dioxid (1' to 500), passing in a zinc probe, then applying the anode of a cataphoric outfit with from 1 to 5 milliampères of current from three to seven minutes (the cathode at the cheek). The object is to form zinc oxychlorid in the apical root canal through electrolytic action. The canal must be regarded as doubtful, but if well opened to the inaccessible portion a trifle of formopercha may be placed on cotton at this point and the balance of the canal be filled with antiseptic temporary stopping. The paraform and cassia in the formopercha are active agents.

A variant consists in the use of embalming paste or Söderberg's mummifying paste, either made stiff and introduced with successive sizes of pluggers, beginning with the largest admissible and proceeding to the smallest, or moistening the canal with the thinner paste and packing a cone into it. The use of such a paste in connection with a cone of gutta-percha is valuable as an agent embalming the fibrils in the dentin of teeth from which living pulps have been removed, or of keeping sterile the tubules of those teeth in which the pulp is gangrenous.

If conditions admit of it, provision for future entrance of the canals

[1] Dental Cosmos, 1905, p. 1196.

should be made, and it is always well to divide the operation of canal filling and crown filling by a short period of time.

Iodoform paste with or without cotton may be placed in the upper third of the canal.

Root Canals in Temporary Teeth.—These may at times be well filled with gutta-percha points, which, if aseptic, do not interfere with resorption, but a material of easier adaptation which absorbs with the root is preferable. The waxes meet the indications, as they can be pumped while fluid from the action of a hot root drier into all inequalities, where they adjust their relation to the soft tissue.

Buckley recommends in cases of chronic abscess the use of a stiff mixture of calcium phosphate and formocresol (formalin, 1 part; cresol, 2 parts), to be packed into the pulp cavity and zinc phosphate flowed over it.

Johnson recommends eucalypto-percha to be pumped into the canals and pressure with temporary stopping to be exerted until the solution appears at the fistula. Such temporary stopping as does not interfere with filling integrity should be left.

There are various other methods of filling root canals, such as driving wood points saturated in carbolic acid into the canals; the use of iodoform paste with or without cotton, or of creosote on cotton (preferably raw cotton); the use of balsam del deserto, etc., which have advocates, but the methods given are those which have had long-continued and successful use.

The Covering of the Root Canal Filling.—The bulb of the pulp chamber may be filled with any of the more solid materials. In case of a strong crown, temporary stopping makes a good occupant of this cavity, although gutta-percha is often used. In the weaker teeth or sometimes for other reasons zinc oxychlorid or zinc phosphate with about 5 per cent. of thymol added while mixing makes a good filling.

Mummification of the Pulp.—In order that time may be saved, efforts have been made to introduce partial removal of the pulp and the treatment of the remaining portion by means of drying agents which shall render it less liable to putrefaction. The method had its origin with Witzel in 1874, and has since been taken up by Miller (1893) and Söderberg (1895).

It consists of partial devitalization by arsenic and the application of a tanning agent against the pulp stumps. Necessarily this causes the shrinkage of the organ, leaving a space about it into which bacteria may possibly find their way. Obviously the nearer the apex of the pulp canal this is carried, the less the danger of subsequent infection. Therefore the logical conclusion is that all remnants of pulp that can be removed should be removed, when a tanning and antiseptic agent that will occupy the canal becomes an excellent root filling. There is little excuse for not carrying the canal work to this point, as the present

methods of canal enlargement render it facile. In some cases, however, Söderberg's method may be of use.

It consists in applying arsenic for a short time to devitalize the pulp bulb only, then applying a portion of the following paste to the pulp stumps:

℞—Aluminis exsiccatis,
Thymolis,
Glycerini āā 3j
Zinci oxidi, q. s. to make a stiff paste.

This is then covered with zinc phosphate and the filling completed. A crystal of cocain may be added to prevent pain. It has been suggested that paraform or a drop of liquor formaldehyd be added for the increased mummifying effect.

Pulp Digestion.—Harlan recommended that the following paste be applied to unremoved portions of dead pulps as a means of digesting them preparatory to root filling:

℞—Papain gr. v
Price's pure glycerin ♏iv
Sol. 1 : 200 hydrochloric acid ♏v—M.

This is applied in the pulp canal, covered with blotting paper, soaked in liquid vaselin, and the whole temporarily sealed for a few days. The pulp is reduced to the consistence of jelly and can be readily washed out.

The method, on the whole, does not seem preferable to either mummification or the Rhein treatment or the formocresol treatment of inextricable portions of pulps in curved roots, etc., inasmuch as the occupancy of a canal by a sterile pulp remnant is better than leaving an empty root canal apex or filling only a portion of it in such manner as to render subsequent treatment almost impossible. In fact, it is better that dentists recognize their limitations and put themselves in position to do future good to the patient, than to blindly obstruct efforts in that direction.

CHAPTER XV

PYORRHEA ALVEOLARIS[1]

By EDWARD C. KIRK, D.D.S., Sc.D.

Definition.—"Pyorrhea alveolaris" is a generic term which, strictly defined, means a flowing of pus from an alveolus. It describes merely a symptom which is usually, but not invariably, attendant upon a variety of gingival disorders. The term is applied in clinical dentistry to a complexus of pathological conditions which more or less clearly indicate a specific disease. As now understood, the term pyorrhea alveolaris includes those cases of morbid action characterized by the following features: Inflammatory degenerative changes leading to a molecular necrosis of the retentive structures of the teeth (their ligament, the pericementum), an atrophy of the alveolar walls, together with a chronic hyperemia of the gum tissue. After a variable period the teeth drop out, and the morbid action ceases with their loss. An examination of the roots of the teeth before or after their exfoliation usually, though not invariably, exhibits deposits of calculi upon their surfaces. The disease is generally, although not always, attended by a flow of pus from the alveoli.

History.—That pyorrhea alveolaris is not a recent disease, or one due to modern constitutional states alone, is rendered evident from the examination of the skulls of ancient as well as modern races. The alveolar processes of many crania widely separated both in time and in locality exhibit marked impairment of structure which bears the closest resemblance to that presented by processes which are known to have been the result of pyorrhea during life.

Recorded observations of this disorder date at least as far back as 1728, when Pierre Fauchard described its essential clinical features, but failed to designate it by any specific term. Following this, communications describing the disease were published by Jourdain in 1778, by Toirac in 1823, and by M. Maréchal de Calvi in 1860, in which it was described as a "conjoint suppuration of the gums and alveoli," *pyorrhée inter-alvéolo-dentaire* and *gingivitis expulsiva* respectively.

[1] The historical portion of this chapter and the definition of the disorder, with some modification of the latter, is the work of the late Prof. C. N. Peirce.

The most important contribution to the knowledge of the nature of the disease which had up to that date been made was by Dr. E. Magitot in 1867. In his paper he describes the disease as being characterized by a slow but progressive inflammation destructive of the periosteal membrane and cementum, proceeding from the neck to the apex of the root and involving the loss of the teeth. From the exact seat of the lesion he designated the disease *ostéo-périostite alvéolo-dentaire.* Soon after the appearance of the periosteal inflammation, it becomes complicated with diseases of the gums and the osseous walls of the alveolus, although these are never primarily the seat of inflammation. Magitot regarded the causes of the inflammation as very complex, and to be sought for not in the teeth and gums, but in certain conditions of the general nutrition. The gouty and rheumatic presented the disease most frequently, although its presence in those suffering from diabetes and albuminuria was extremely common. The deposition of tartar on the roots of the teeth, which might at first glance be regarded as playing an important part in the causation of the disease, Magitot considered as accidental and not to be looked upon as a causative agent. With reference to the efficacy of any treatment, however, he advised the removal of the tartar as an indispensable preliminary. The points of diagnosis differentiating between this condition and the former, that of gingivitis, however severe, were also clearly recognized and noted.

Following Magitot's able paper was one by Serran in 1880, in which the author took exception to certain of Magitot's views, as well as to the term by which the latter proposed to designate the disease. He recognized, however, that the disease was most common in middle life and occurred principally among the gouty, the diabetic, and the albuminuric. He believed that the primary manifestation was a local congestion of the gums, followed by an exudation into the peridental membrane which destroyed its vitality and led to the formation of pus and all the other symptoms and pathological conditions characteristic of the disease. A commission composed of MM. Desprès, Delens, and Magitot was appointed by the Société de Chirurgie of Paris to consider the statements of Dr. Serran. In this report[1] they denied the *gingival* origin of the disease, and stated their belief that the periosteal membrane and the cementum were the primary anatomical seat of the lesion; that the succession of morbid phenomena completely precluded the idea of an initial gingivitis; that the disease begins without any trace of congestion of the gums; that after its formation the pus burrows toward the gingival border, which it detaches—without, however, for a time

[1] Bulletins et Mémoirs de la Société de Chirurgie, tome vi, p. 411.

destroying its normal aspect; that only after considerable augmentation of the flow of pus and the loosening of the teeth do the gums become implicated; that the disease had nothing in common with the hypothesis of a gingival malady, and that it is most frequently a manifestation of a general state, or a diathesis.

These were the views entertained and published by French surgeons on the nature of "pyorrhea alveolaris" about the period when the disease began to receive consideration from American dentists. Although pyorrhea alveolaris had long been recognized in the United States and various observations regarding its pathology and treatment had been published, it was not until Dr. John W. Riggs, of Hartford, Conn., in October, 1875, read a paper before the American Academy of Dental Surgery, entitled "Suppurative Inflammation of the Gums and Absorption of the Gums and Alveolar Processes," that the disease began to attract the attention its gravity merited. Notwithstanding the views entertained by Magitot and others regarding the constitutional character of the disease, Dr. Riggs in his communication[1] emphatically denied that the disease is an affection of the bone or of the gums, or that it is hereditary or constitutional, but, on the contrary, that it is the roughened teeth themselves, in consequence of the accretions from whatever source derived, which are the exciting cause of the inflammation; that it is purely local in origin, the result of concretions near and under the free margins of the gums, the removal of which even in the third stage is followed by cure.

In 1877 Dr. F. H. Rehwinkel[2] entered his protest against the theory of the local origin of the disease, and endeavored to prove that it not only may but does exist independently of foreign deposit and must depend on other than merely local causes, and that it is an hereditary and constitutional disease.

Dr. L. C. Ingersoll, in 1881, published a paper entitled "Sanguinary Calculus,"[3] in which it was stated that the persistent flow and discharge of pus along the side of the tooth was caused by an inflammation and ulceration at or near the apex of the root; as a result of which molecular death the liquor sanguinis escaped from the bloodvessels into the surrounding tissues and became disorganized, the lime salts crystallized on the surface of the roots, and formed the deposit which from its origin he designated "sanguinary calculus." This deposition he regarded as entirely distinct from salivary calculus, and as derived from the

[1] Pennsylvania Journal of Dental Science, vol. iii, p. 99.
[2] Report of the Committee on Pathology and Surgery, Trans. American Dental Association, 1877, p. 96.
[3] Ohio State Journal of Dental Science, vol. i, p. 189.

blood—the result of inflammatory action and not its cause. In other words, he held that pyorrhea is a local disease but beginning centrally; that is, at or near the apex of the root.

In 1882 Dr. A. Witzel read a paper before the German Society of Dentists,[1] in which it was asserted that the primary pathological change was an inflammation and caries of the alveolar border followed by a deposit just beneath the free margins of the gums, which became retracted and reverted. The entrance of micro-organisms into this carious region developed pus which became more or less infectious. In consequence he termed the disease "infectious alveolitis." He regarded the disease as a primary local alveolitis, having no constitutional relations whatever, a molecular necrosis of the alveoli or caries of the dental sockets produced by septic irritation of the medulla of the bone.

In 1886 Dr. G. V. Black prepared probably the most exhaustive paper in print in the United States, wherein pyorrhea alveolaris is treated as a local disturbance.[2] Calcic inflammation and phagedenic pericementitis are the terms he employs to indicate its character. Although he believes it to be wholly local, he thinks a serumal or sanguinary deposit may be closely allied with its origin. He describes it as a destructive inflammation of the pericemental membrane, distinct from other inflammations of this tissue, although having many features in common with them. The disease, he estimates, is essentially one of the peridental membrane rather than of the alveolus, although the destruction of these two structures is so nearly synchronous that it is difficult to say which has gone first.

In 1886 Dr. W. J. Reese read a paper before the Louisiana State Dental Association on "Uremia and its Effect on the Teeth,"[3] in which the chemical, physiological, and pathological relations of uric acid to the general nutrition were discussed. In this communication Dr. Reese expressed the opinion that the inflammation of the pericemental membrane, followed by suppuration and disorganization when in contact with the secretions of the mouth, is caused by the deposition of uric acid derived from the blood; that the disease should be termed "phagedena pericementi;" that "pyorrhea alveolaris" is a misnomer. He also stated that while the tophus on the roots of the teeth is the usual concomitant of uric acid, it is not necessarily so, but that absorption of the pericemental membrane may take place without any deposit. Although

[1] Vierteljahresschrift für Zahnheilkunde, 1882; British Journal of Dental Science, vol. xxv, p. 153.

[2] Diseases of the Peridental Membrane having their Beginning at the Margin of the Gum, American System of Dentistry, vol. v, p. 953.

[3] Dental Cosmos, vol. xxv, p. 550.

a local treatment was advocated, he stated that without systemic or constitutional treatment the return of the trouble may be expected.

Dr. John S. Marshall, in 1891, expressed his conviction that pyorrhea has a constitutional origin and is closely allied to the rheumatic or gouty diathesis; "that the deposition of the concretions upon the roots of the teeth in those localities not easily reached by the saliva, or in which the presence of the saliva would be an impossibility, is due to the causes which produce the chalky formations found in the joints and fibrous tissues of gouty and rheumatic individuals."[1]

C. N. Peirce, in a series of papers published during 1892–94–95,[2] presented a number of clinical and pathological facts which in their totality it was believed established a kinship between pyorrhea alveolaris or hematogenic calcic pericementitis and the constitutional state familiarly known as the gouty or uric acid diathesis.

Recent literature by American writers has dealt largely with the problem of the etiology of the disease in question and has been principally concerned in determining whether it is of constitutional origin or of local origin, or of both. Of the more important recent writings on the subject may be mentioned those of Drs. E. T. Darby, H. H. Burchard, G. V. Black, E. S. Talbot, M. L. Rhein, E. C. Kirk, James Truman, Junius E. Cravens, Louis Jack, R. R. Andrews, and R. Ottolengui.

Terminology.—No disease in the whole domain of surgery has received so many and such diverse names as the one under consideration. Each succeeding title was an attempt at the production of a comprehensive descriptive designation of the disease, but when it is recognized that the essential nature of the pathological processes involved is, even now, not fully made out, it is evident that the many names simply represent as many diverse views and can therefore have no permanency, nor do they, indeed, deserve any.

The following is a fairly complete list of the synonyms of the disorder: Suppuration conjointe, pyorrhée inter-alvéolo-dentaire, gingivitis expulsiva, ostéo-périostite-alvéolo-dentaire, pyorrhea alveolo, cemento-periostitis, infectioso-alveolitis, pyorrhea alveolaris, calcic inflammation, phagedenic pericementitis, Riggs' disease, interstitial gingivitis, hematogenic calcic pericementitis, blennorrhea alvéolaris, gouty pericementitis.

It should be noted that pyorrhea alveolaris (flowing of pus from the alveolus) is a generic term carelessly used to designate a

[1] The Rheumatic and Gouty Diathesis, with its Manifestations in the Peridental Membrane, Transactions American Medical Association, 1891.

[2] International Dental Journal, vols. xiii, xv, and xvi.

group of disorders all of which result in loss of the teeth by destruction of their retentive tissues; also, that this loss may and often does occur without the obvious production of pus as an attendant symptom. The term pyorrhea alveolaris is, therefore, inaccurate as descriptive of the disease and unscientific except as it is indicative of a symptom common to several disorders; but, inasmuch as the designation is in common and general use, and still further because the etiology of the several gingival disorders so described still remains to be scientifically demonstrated, it will be more convenient to retain "pyorrhea alveolaris" as a general designation until a more accurate terminology based upon the known etiology and pathology of these destructive inflammatory alveolar disorders becomes possible as the result of further study and investigation. It should, therefore, be understood that the term pyorrhea alveolaris is used throughout this chapter in its general sense as applied to the group of disorders having the clinical characteristics specified under "Definition" in the opening paragraph of this chapter.

General Considerations.—One fact is clearly evident in all forms of pyorrhea alveolaris, viz., that it is an inflammatory disorder. It may be acute and violent, running a comparatively short course, or it may be chronic over a long period; the evidences of inflammatory activity may be so slight as to escape other than critical notice, yet the morbid process in its clinical manifestations and in its destructive results falls strictly within the limitations prescribed by the modern definitions of inflammatory action.

Inflammation, as defined by Adami,[1] is "the succession of changes which constitute the local effort at adaptation to the changes initiated by actual or referred injury to a part; or, in short, *the local adaptive changes resulting from actual or referred injury.*" "Anything which causes local injury to the tissues is a cause for inflammation, be it a mechanical trauma, a physical insult, as by heat, cold, or electricity, a disturbance brought about by altered metabolism and abnormal internal secretions or by bacterial or microbic invasion and growth. This last is the commonest cause of acute reaction, and differs from the physical and mechanical causes (although not from metabolic disturbances) in that, as a cause, it is not of momentary duration, but continued. It is not the mere physical entry of microbes into the tissues that induces inflammation, but the liberation by them of their products in growth or disintegration. And so long as those products are being liberated, for so long is the cause in action. It differs from the metabolic causes

[1] Principles of Pathology, vol. i, p. 377.

in that the latter induce tissue irritation of a milder grade, and so do not induce acute but rather chronic reactions."

Viewed as an inflammatory process we have, then, in the study of pyorrhea to regard its clinical or objective phenomena as reactions of the retentive tissues of the teeth toward injuries inflicted by mechanical trauma, physical irritants, altered metabolism, the toxic effects of altered secretions, or by the toxic products of microbic or bacterial invasion. Any of these agencies, severally or collectively, may induce such changes in the retentive structures as will lead to their molecular necrosis and the ultimate exfoliation of the teeth, the process constituting comprehensively what we know as pyorrhea alveolaris.

Pyorrhea alveolaris is a condition of disease as opposed to health of the tissues concerned in the fixation or retention of the teeth in the alveolar borders. It is a disturbance of the normal health of these tissues.

The condition which we speak of as health may be defined in its ideal sense as that condition or state which is the resultant of the harmonious concurrent or interaction of all those factors necessary to the normal functioning of a tissue or organism, or, shortly, health is a state of metabolic or physiological equilibrium. Any definition of health as applied to an organism or to a tissue must necessarily be imperfect in that it cannot, in the nature of the case, be absolute, for the reason that the functioning of a tissue or its cells, as well as of the entire organism, is dominated by the factor of vitality or life, a phenomenon which in the present state of human knowledge eludes definition. As a metaphysical formula the working definition of life proposed by Mr. Herbert Spencer affords assistance in arriving at a conception of the meaning of that ideal state of physiological functioning which we speak of as health. Spencer defines life as "the continuous adaptation of internal relations to external relations." It will be seen that this conception includes, as all attempts at the definition of vital action must include, a recognition of the variability of vitality. Health, then, which is a condition of life dependent upon physiological balance or harmony of metabolic activity (internal conditions) in relation to environment (external conditions), can never be regarded as a condition or state of stability, but rather as a condition of continuous variability. The metabolic equilibrium of health is therefore to be understood not as a fixed, but rather as an unstable or moving equilibrium.

The equilibrium of health finds certain analogies in that of the bicycle in action. The energy of the rider imparted to the mechanism causes it to maintain its balance and to advance along a course which approaches

a straight line, this approach being directly proportionate to the energy which the machine receives. If the energy falls below that required to maintain equilibrium, the machine drops to the ground. External agencies, such as inequalities in the road bed, obstructions to the smooth revolution of the wheels, deviations of the course involving ascent of surface inclines, high winds, these or any of the numerous environing conditions which may beset the cyclist, demand recurrent accesses of energy in order to maintain equilibrium of the machine and propel it upon its course. Or if, from fatigue or other internal causes, the cyclist becomes incapable of delivering to his wheel the necessary potential, then in that case also the machine falls to the ground.

The study of disease action as it is expressed in pyorrheal conditions of the retentive tissues of the teeth is a study of the adaptive reactions of these tissues to those agencies which tend to destroy their normal physiological equilibrium, the phenomena attending the effort of the forces of the tissues to oppose injuries, be they mechanical trauma, physical or chemical.

It should be clearly understood that no sharp dividing line can be drawn between the ideal state which we call health and those departures from it which we call disease. No two individuals are alike in any respect, for which reason the standards of physiological equilibrium, or of health, differ as individuals differ. Nor in the same individual are the physiological activities continuously in normal equilibrium. Variations from the normal brought about by the play of environing conditions are constantly producing departures from normal states as a necessary result of the process of living. These departures from normality vary by insensible degrees from little to greater, so that it is impossible to draw a sharp line of demarcation and define at what point we cease to deal with the physiological state and are confronted with the pathological. This general fact applies not only to the organism as a whole, but to its component tissues as well, hence in the study of the group of gingival disorders here considered as pyorrhea alveolaris we are confronted not only with a variety of lesions, but an infinite gradation in intensity of the phenomena involved.

ETIOLOGY

The study of pathological lesions must have its basis in a knowledge of the anatomical structure of the tissues involved, hence an understanding of the nature of the destructive processes which produce

necrosis of the retentive tissues of the teeth, and their final exfoliation can only be intelligently arrived at after a comprehension of the structure and function of the retentive tissues of the teeth has been acquired.

Broadly speaking, the tissues concerned in the inflammatory processes under consideration, and collectively referred to as the retentive tissues of the teeth, are the bony alveolar structures with their overlying gum tissues and the ligamentous tissue by which the teeth are attached to their alveoli, known as the pericemental or peridental membrane. These with their vascular and nervous supply are all involved in the various pyorrheal affections, while in certain aspects of the disorder a group of peculiar structures embedded in the pericementum, probably cellular remnants of the embryonal structure known as the epithelial sheath of Hertwig, described by G. V. Black as lymphatic glands,[1] play a most important part.[2]

External Factors.—As a whole, the teeth and their associated tissues are fixed in an environment which is the source of a variety of irritative factors, many of which are capable of exerting harmful influences and, among other injurious results, of giving rise to the destructive phenomena of pyorrhea alveolaris. Since Antoni van Leeuwenhoek, the linen-draper of Amsterdam, in 1683, announced to the Royal Society of London his discovery of "animalculæ," which he had found in the "materia alba," or white deposit scraped from the surfaces of his own teeth, the investigation of the bacterial forms found in the human mouth has progressed until at the present time it is a well-established fact that the human mouth is the breeding ground or incubator for an extensive variety and infinite number of bacterial forms, many of which are the known exciters of disease action both locally in the mouth itself and in the more remote organs and tissues of the body.

No human mouth is ever free from bacterial contamination at any time from birth to death, and no method has as yet been devised by which complete sterilization of the oral cavity may be safely accomplished. Nevertheless, very many mouths are free from any evidence of bacterial invasion and consequent inflammatory reaction of the tissues, notwithstanding the fact that even in such mouths the presence of pathogenic bacteria may be abundantly demonstrated. Infection of the oral tissues in such cases is prevented by the internal resistive powers of the dental and oral tissues, as infection of the other tissues of the healthy body is

[1] A Study of the Histological Characters of the Periosteum and Peridental Membrane, Chicago, 1887, p. 90. The Fibers and Glands of the Peridental Membrane, Dental Cosmos, 1899, vol. xli, p. 101.

[2] For a detailed description of the retentive structures of the teeth the reader is referred to pp. 94 to 115 of Chapter II.

prevented by the adaptive agencies of the vital mechanism. The sum total of the resistive forces against the invasion of pathogenic bacterial elements is termed immunity, a state which to a large degree is one of the conditions of normal health, in which instance it is designated as natural immunity, or, within certain limits, the condition may be artificially produced, and it is then designated as acquired immunity.

It will be seen from the foregoing that bacterial invasion of the tissues and consequent inflammatory reaction in them depends upon the overpowering of the internal resistive forces of the tissues by pathogenic bacteria endowed with a disease-producing potential of relatively higher intensity than that of the resistive power of the tissues. Wherever bacterial invasion and consequent inflammatory reaction in the tissue results, it means that the defensive powers of the tissue have been overcome by the invading organism, the equilibrium of tissue health has been destroyed, and a condition of disease has been established.

The causes of pyorrheal inflammation are rarely, if ever, simple in character in the sense that they are the direct and unaided effects of specific infection in a normally healthy tissue. Various contributory or predisposing factors are usually concerned in the production of these gingival and alveolar inflammations. The factors which contribute to the bacterial invasion of the gingival tissues may be broadly classified as external and internal.

Among external causes may be included mechanical injury to the tissues involved. Any agencies which injure the gingival tissues to the extent of creating in them a traumatic lesion may serve as a predisposing cause of pyorrhea alveolaris. Injury to the tissues, depending upon its degree and seriousness, will produce either cell death with total loss of resistance, or if not cell death, then disturbance of cell function, with greatly diminished resistance to bacterial invasion.

Injudicious application of ligatures or clamps in adjusting the rubber dam, similar maltreatment of the pericemental membrane at its cervical attachment by the improper application of band and other forms of matrices, and, above all, the physical insult to the pericementum resulting from an unskilfully fitted artificial crown, especially of the banded type, are fruitful sources of traumatic injury which are definitely known to be predisposing causes of pyorrhea alveolaris.

Tartar as a Predisposing Cause.—Among the traumatic predisposing causes of pyorrhea alveolaris, none is so frequent or so generally noticeable as the injury to the retentive tissues of the teeth produced by accumulation of salivary calculus, or tartar. Salivary calculus is here classified as a traumatic irritant predisposing to pyorrhea alveolaris,

for the reason that the encroachment of growing accumulations of tartar is not alone sufficient to account for the inflammatory reaction which accompanies it, and further, because the pus production associated with this form of pyorrhea is necessarily a result of bacterial infection. The exact nature of the process of tartar formation has not as yet been made out with definite clearness. It is known in general that salivary calculus or tartar is composed of calcium phosphate and carbonate with occasionally other allied salts formed into a concretion by the mucinous elements of the saliva, and that it contains entangled in its structure the bodies of a variety of bacterial forms. The earthy salts which enter into the composition of salivary calculus are derived from the saliva, where, under normal conditions of health, they are retained in solution, but in certain unknown nutritional changes which bring about alterations in the composition of the mixed saliva, a portion of the dissolved calcium salts undergoes precipitation upon surfaces of the teeth protected from the friction of the tongue, lips, and cheek tissues, these deposits undergoing an incremental growth until in some instances they attain a relatively enormous size.

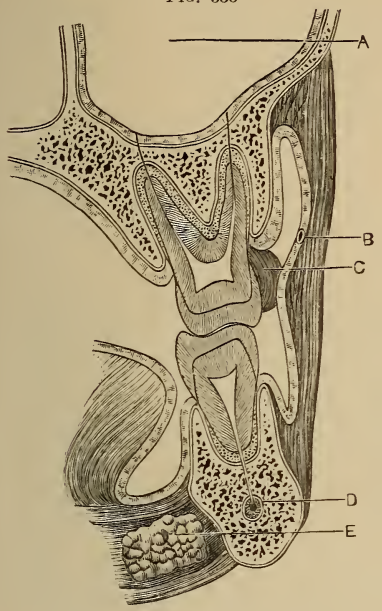
Deposits of tartar upon the teeth present a large variety of forms and marked differences in position and physical characteristics, but whenever the deposit impinges upon the retentive tissues of the teeth it acts as a traumatic irritant, which interferes with the nutrition of the soft tissues, decreasing their normal resistive power, and by so doing renders them susceptible to invasion by pathogenic organisms, thus setting up inflammatory reactions, among which are certain forms of pyorrhea alveolaris. There is nothing in the composition of salivary tartar, as such, that can cause chemical irritation. Its action is distinctly and simply mechanical or traumatic, and as a causative factor in the production of marginal inflammation it must therefore be classed as among the predisposing causes. The exciting or immediate cause of the inflammatory reaction is bacterial infection of the tissue injured by the tartar deposit.

Deposits of tartar are classified, with respect to their origin, as *salivary calculus* and as *serumal* or *sanguinary calculus*, according as the deposit has been derived from the saliva or from the blood plasma respectively.

While it has been definitely determined that deposits of calculus occur upon the roots of teeth in which the possibility of access of saliva has been excluded, it has not by any means been clearly shown that the thin scaly deposits of tartar found upon the roots of teeth in cases of pyorrhea alveolaris nor the thin scale-like ring of tartar found encircling the necks of teeth below the gingival margin in similar cases,

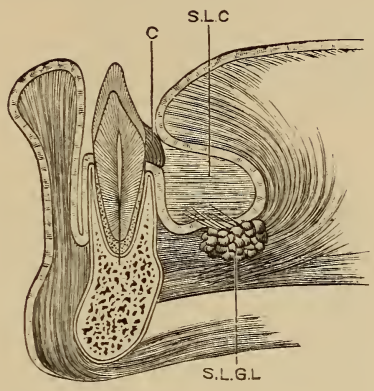
owe their origin to the blood plasma and are, therefore, properly designated serumal tartar, as such deposits are ordinarily classed, for the reason that in both these instances there is more or less free access of saliva to the region of the deposit, and no tartar deposit can with accuracy be described as serumal tartar unless absolute exclusion of saliva from the region of the deposit is demonstrable.

Fig. 535



A, maxillary sinus; *B*, duct of Steno; *C*, parotid calculus; *E*, submaxillary gland.

Fig. 526



C, calculus; *S.L.C.*, sublingual cavity; *S.L.G.L.*, sublingual gland.

The mere physical differences observed in tartar deposits are not in themselves sufficient to definitely determine either the salivary or the blood origin of the deposit respectively. Differences in the physical characteristics of tartar deposits are due, among other things, to variations in chemical composition and to the rate of growth or formation of the deposits, and these factors are in their turn dependent upon the composition of the fluids from which the deposits or precipitation of earthy salts takes place, while the composition of these fluids, finally, is dependent upon the nutritional state of the individual upon whose teeth the deposits are formed.

In certain individuals the accumulation of tartar as a deposit from the saliva is constant and relatively rapid. In such cases the accumulation is greatest upon tooth surfaces which face the orifices of the ducts of the parotids, the so-called ducts of Steno, and upon the lingual

surfaces of the lower incisors, which are opposite the orifices of Wharton's ducts (Figs. 535 and 536). In these localities precipitation of salivary tartar occurs most frequently, and in many instances the deposits grow to enormous size (Figs. 537 and 538). That the deposit is salivary in its origin is shown by the commonly observed fact that it will take place upon an artificial denture as readily as upon the necks of the natural teeth (Fig. 539). The salivary deposit may be small in amount and relatively slow in accumulating, or it may, on the contrary, be large in amount and accumulate rapidly; and there also appears to be a fairly definite correspondence between the density and

FIG. 537



FIG. 538



Specimens of parotid tartar; actual size.

FIG. 539



Partial denture clasped to first and second molars, which have been lost by deposition of parotid tartar.

Fig. 540



Fig. 541



Fig. 542



hardness of the deposit and its rate of formation, the density being in inverse ratio to the rapidity of its formation. Figs. 540, 541, 542,

Fig. 543



Fig. 544



Fig. 545



543, 544, and 545 show various commonly observed forms of salivary tartar deposition. Another important factor is, however, concerned

in tartar formation, one which has much to do with its physical characteristics and incidentally with its rate of formation, and that is the relative quantity of mucin or other colloids in the medium from which the tartar is precipitated.

Nature of Tartar Composition.—In 1858 Mr. Rainey, of London, made the important discovery[1] that when certain earthy salts are precipitated in a medium containing a colloidal substance in solution, the resulting precipitate was profoundly modified in the form of its ultimate particles which instead of being crystalline in character were in the form of minute spheroidal masses, and that as the precipitation progressed the spheroidal masses increased in diameter so that adjoining masses grew into contact, and, by accretion of new material, they coalesced until finally the coalescence of a large number of individual spherules gave rise to the formation of mulberry-like masses. Mr. Rainey's experiments were made with gum arabic as the colloidal material in the menstruum from which the precipitation of earthy material was made, and microscopic examination of the spheroidal concretions thus produced showed a laminated or onion-like structure quite analogous to that found in the shells of hen's or bird's eggs, the shells of molluscs, calcareous concretions in the urine of the horse, etc. Contemporaneously with Rainey's investigations, Professor Harting,[2] of Utrecht, pursued the same line of inquiry, and not only confirmed the observations of Rainey, but greatly extended his results by showing that with animal colloids, such as egg albumin, blood serum, or a solution of gelatin, a much greater variety of forms may be produced, many of them closely resembling concretions only found in the animal body. Professor Harting brought out the further fact that the resistance of these spheroidal concretions to the solvent action of acids was greater than that of the precipitates formed from the same material in the absence of colloids, and that after treatment by acids until all visible particles of calcareous matter were dissolved out there remained a basic substance or matrix upon which, although it still retained its original form, the acid apparently had no further action, and to this residue of insoluble material he gave the name "calcoglobulin;" he also made the further important observation that when various coloring matters, such as madder, logwood,

[1] See his treatise, On the Mode of Formation of the Shells of Animals, of Bone, and of Several other Structures by a Process of Molecular Coalescence Demonstrable in Certain Artificially Formed Products, 1858, and his Further Experiments and Observations, in Quarterly Journal of Microscopical Science, 1861, n. s., vol. i, p. 23.

[2] See Professor Harting's Recherches de Morphologie synthétique sur la production artificielle de quelques Formations Calcaires Inorganiques, publiées par l'Académie Royale Néerlandaise des Sciences, Amsterdam, 1872, and Quarterly Journal of Microscopical Science, vol. xii, p. 118.

or carmin, were added to the solution in which the precipitation was taking place the concretions took on the hue of the dye employed, *i. e.*, that they were readily susceptible of pigmentation. The same line of inquiry was confirmed and further carried out by Dr. W. M. Ord[1] with reference to the formation of urinary and other calculi.

The data derived from the researches of Rainey, Harting, and Ord have served to explain the chemical principles involved not only in the various phenomena of normal calcification of the several hard or calcified tissues of the animal body, but also of the numerous pathological concretions found associated with disease processes, such as vesical, renal, and biliary calculi, the calcification of the debris of suppurative processes in various tissues and organs, and the calculous deposits upon the teeth. The essential factor in all of these processes is the precipitation of a relatively insoluble earthy substance in a medium containing colloid material, such as protoplasm, albumin, mucin, casein, and allied organic substances, which unites with the inorganic element to form compounds having the physical characteristics of calcoglobulin, and likewise its habit of forming spheroidal masses that grow by accretion and coalescence into irregular mulberry-like concretions.

The mixed saliva contains a variable amount of calcium phosphate in solution, but the exact nature of the dissolved phosphate has not been definitely determined. It is, however, known that tricalcic phosphate, $Ca_3(PO_4)_2$, is soluble in nearly all acids and is soluble even in carbonic acid, a fact determined by the English chemist, W. H. Pepys, Jr., as early as 1803.[2]

As the saliva contains carbon dioxid in solution, it has been assumed, with some justification, that the escape of the carbon dioxid which was the solvent of the calcium carbonate and tricalcic phosphate, causes a precipitation of those salts in the presence of the colloid mucin, in combination with which it deposits as tartar upon the teeth. While the foregoing may serve as an explanation of one method of salivary tartar formation, an almost unlimited variety of conditions are probable which involve the fundamental principle of precipitation of tricalcic phosphate from solution, and when this precipitation takes place in any colloidal medium the result is a calcic concretion modified in its physical characteristics by the conditions under which the precipitation and concretion occurred.

[1] On the Influence of Colloids upon Crystalline Forms and Cohesion, London, 1879.

[2] The Natural History of Diseases of the Human Teeth, by Joseph Fox, London, 1803, p. 94.

H. H. Burchard[1] proposed an explanation for the formation of salivary tartar deserving of consideration, viz., that inasmuch as fermentative processes in the oral cavity give rise to acids, and particularly lactic acid, these acids cause precipitation of the mucin of the saliva as a coagulum which entangles in its structure calcic phosphate and carbonate, and this mass by gradual condensation increases in density to the extent of forming the coherent deposit known as tartar.

It is also known that in many individuals in whose mouths proteid substances are undergoing decomposition the exhaled breath contains appreciable quantities of ammonia which may be recognized by Nessler's reaction or by the murexid test. It is further known that ammonia will cause a precipitation of calcium phosphate from its acid solutions, as calcium ammonium phosphate, or when magnesium is present ammonium magnesium phosphate, so-called triple phosphate, is also precipitated, and this latter salt has been identified as one of the constituents of certain varieties of tartar.

As the earthy phosphatic salts of the saliva must in the nature of the case be retained in a state of solution in the saliva by virtue of some form of acid combination either as simply dissolved in carbon dioxid or in the form of acid calcic phosphate, a soluble salt, then any agency which would eliminate the acid element, *e. g.*, the escape by evaporation of the contained carbonic acid, or again the presence of ammonia in the breath, or the introduction of a basic substance into the saliva, would lead to precipitation, as already shown.

An interesting example of the production of tartar by neutralization of the acid solvent element of the salivary phosphates is furnished by the tartar deposits found upon the teeth of the betel-nut chewers of the Malay Archipelago, India, and Indo-China. The habit of betel-nut chewing is practically universal among all classes in the regions mentioned.

The masticatory bolus is prepared by wrapping slices of betel-nut, the fruit of the areca palm, in a leaf of the piper betel, or Pinang, a climbing shrub cultivated in the East to a prodigious extent for the purpose. The slices of areca nut are first sprinkled with a little lime to develop the desired flavor. The chewing of the bolus causes a deep red staining of the teeth and the rapid accumulation of large, dense deposits of tartar which at first are red, then finally become a dark chestnut brown or black. The encroachment of the tartar is

[1] See Origin of Salivary Calculus, by Henry H. Burchard, Dental Cosmos, 1895, vol. xxvii, p. 821. Also Varieties of Dental Calculi, by the same author, Dental Cosmos, 1898, vol. xl, p. 1.

FIG. 546



Lower incisor almost completely encrusted with betel tartar.

FIG. 547



Lower canine with thick incrustation of betel tartar.

FIG. 548



Lower bicuspid with extensive deposit of betel tartar.

FIG. 549



Lower canine covered with betel tartar.

so rapid and destructive that habitués frequently become toothless at twenty-five years of age. Figs. 546, 547, 548, and 549 show examples of

FIG. 550



FIG. 551



Upper and lower incisors lost from deposit of betel tartar.

individual teeth lost from betel-nut tartar, and Figs. 550 and 551 the upper and lower incisor teeth of an individual similarly lost, but which

during the loosening stage had been ligatured with fine brass wire by a native dentist as a temporary support, the whole group of incisors being later exfoliated *en masse*. It is highly probable that the use of the lime in connection with the betel-nut furnishes the necessary basic element to throw down the earthy phosphates of the saliva as tricalcic phosphate in the form of tartar, just as the ammonia of the breath performs an analogous function in the precipitation of tricalcic phosphate and triple phosphate as elements of tartar formation.

Subgingival Tartar.—The chemical principles governing the precipitation of earthy phosphates and carbonates directly from the saliva in the production of true salivary tartar govern also the production of the girdle-like concretions that are found encircling the teeth at and below the anatomical neck and beneath the gum margin. Deposits of subgingival tartar differ markedly in their physical characteristics from true salivary tartar, being denser in structure, slower of formation, darker in color, and more firmly adherent to the tooth. These differences are most probably due to the fact that they are deposited in a region rich in mucin, which exudes freely from the mucinous acini embedded in the marginal gum tissue, and possibly also from the gland-like structure encircling the alveolar border known as the gland of Serres. The subgingival deposits are always accompanied, and, indeed, are usually preceded, by a marginal catarrhal inflammation, which induces an exudation of mucus rich in colloidal material, which is the binding material of the tartar deposit, giving to it the resistant quality and hardness characteristic of the deposits found in these locations. The peculiar dark brown or greenish coloration is derived from the hemoglobin exuded from the inflamed marginal gum tissue, which, in contact with the hydrogen and ammonium sulphid, which are the end products of putrefactive decomposition of proteids, becomes sulfomethemoglobin, the same compound which produces the dirty brown or greenish discoloration so often found at the necks of teeth in cases of marginal gingivitis.

While there are doubtless a variety of conditions which lead to precipitation of the earthy salts of the saliva in combination with the colloidal mucin, thus producing deposits of infinite variety in physical characteristics, the deposits, generally speaking, when first formed, are soft and friable, and are then readily removed by appropriate instrumentation; but they tend to grow denser and harder as condensation of the mass in course of time proceeds, until in some instances they appear to be as resistant to cutting instruments as the cementum of the tooth root to which they are attached. On the other hand, the

larger salivary calculi of rapid growth are generally friable and chalky in texture, showing a relatively less amount of organic colloidal binding material in their structure, the precipitation having occurred in a saliva containing a deficiency of the mucinous element.

The extent of the inflammatory reaction induced by the impingement of salivary calculus upon the gingival tissues varies between wide extremes from a slight superficial gingivitis to an active, necrotic, suppurative inflammation which is a true pyorrhea alveolaris. In cases where the resistive forces of the gingival and alveolar tissues are of normal standard the destructive process initiated by the tartar deposit is superficial and ulcerative in type. On the surface of the tissue immediately below the surface of contact of the deposit an ulcerative destruction of the tissue elements takes place, the area of engorgement, recognizable as a red line, is quite shallow, with normal healthy tissue immediately below it. When the impinging mass of tartar is carefully removed and the contact surface tissue is examined, it will show a denuded ulcerating appearance with frequently the evidences of necrotic tissue debris and pus distributed over the exposed area. If the tartar deposit has been a sufficiently large one, its surface of contact with the soft tissue will frequently show distinctive evidences of pus formation, the exudate being of a characteristic dark greenish or yellowish-brown color. Where the deposit is permitted to remain and to increase in size, the ulcerative process continues until the retentive structures of the involved teeth are completely destroyed and the teeth are exfoliated. The characteristic distinction between this type of destructive inflammatory disease of the retentive tissues of the teeth due to deposits of salivary tartar and those of the graver and more intractable class of pyorrheal disorders of the same structures is the superficial and ulcerative character of the inflammatory lesion in the former. The injury caused by the impingement of the tartar deposit has damaged the subjacent tissue only upon its surface, consequently the bacterial invasion of the damaged tissue has been little more than superficial; the defensive forces of the underlying healthy tissue limit the bacterial invasion to the layer of cells which were functionally disabled as the result of encroachment by the tartar deposit.

Where the inflammatory process has not destroyed the mechanical efficiency of the attachment of the tooth to its alveolus, the disease condition is readily curable by the removal of its cause.

TREATMENT

The operation of removing tartar deposits is commonly described as "scaling the teeth," and the instruments employed specifically for that purpose are designated as scalers.

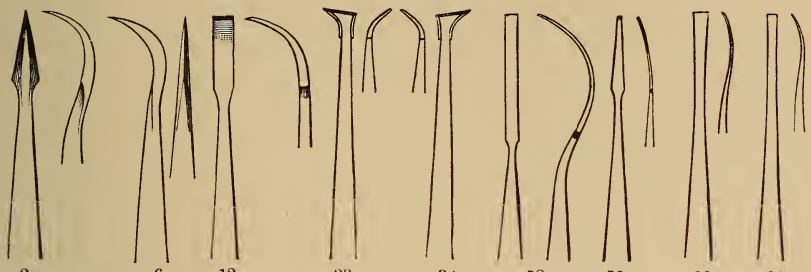
Instruments.—For the removal of large concretions of tartar a few simple forms of scalers are sufficient, as indicated in Chapter IV, Fig. 100, but for the removal of smaller deposits, especially those situated below the anatomical neck of the tooth, an outfit of more delicately constructed instruments, a sufficient number of them having curvatures of shank so contrived as to admit of ready application to all the surfaces of all of the teeth, should form part of the armamentarium of every practitioner who attempts to effectively perform the operation of scaling.

Two types of effective cutting edge should be available in connection with the several forms of instrument shank comprising the operator's outfit of scalers, viz., the type which is used for a pushing cut and the type used for a pull or drawing cut. Certain scaler points may combine both possibilities: for example, when the blade of the scaler is turned to an exact right angle with the shank and its end is then ground squarely across, it forms an instrument with a double cutting edge that may be effectively operated for either a push or draw cut when due consideration is given to the angle at which either of the effective cutting edges is applied to the tooth root. Instruments to be used exclusively for draw cutting or scraping should be given a slight bevel in the direction toward which the cutting is done, while those which are to be operated with a pushing force are most effective when the ends are ground square, although some operators prefer a slightly bevelled cutting edge even in scalers of the push cutting type. Whatever may be the choice as to angle of edge, it is essential that the edge be kept sharp if effective work is to be accomplished with it. Besides proper curvature of shank and character of working edge, it is of paramount importance that the working ends of root scalers be so delicately fashioned that they may be readily inserted to the ultimate depth of pyorrheal pockets without unduly disturbing the pocket or wounding the gum tissue, and it is equally important that they be so tempered that they will not break or permanently bend in use. The necks and shanks should be given a blue spring temper and the cutting ends a light brown or straw color. It is not necessary, nor is it desirable that the points should be left full hard, as in certain enamel cutting instruments.

Finally, the matter of handles is by no means unimportant, for the

reason that in the most difficult and delicate part of the operation of root scaling the operator must be guided by his tactile sense alone in locating the deposits and determining when the root surface is smooth and free from concretions. For this reason the handle of the instrument must be of such size, weight, and form as will interpose the least possible barrier to the accurate transmission of the tactile impression. The

FIG. 552



Scalers.

character of instrument handle is largely a question of individual experience and experiment, and each operator, especially those who to a greater or less extent specialize in the treatment of pyorrhea cases, should discover by careful study and experimentation for himself the type of scaler handle best adapted to his individual use, and through which he can best receive an intelligible understanding of the conditions

FIG. 553



Abbott's scalers.

FIG. 554



Darby-Perry scalers.

he has to meet in the removal of root deposits by instrumentation, and, above all, his equipment of instruments should be ample to enable him to meet all operative requirements.

A selection of twenty-five scalers which will enable the beginner to meet ordinary conditions is shown in Figs. 552 to 558. The numbering is that of the manufacturers' catalogue, which has been retained for

identification. This equipment should be added to as the need for more specialized forms arises and after experience has developed facility in the use of those in the collection illustrated.

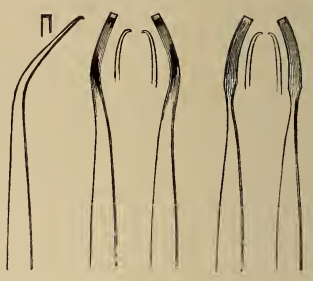
Fig. 555



5 6 7

Harlan's scalers.

Fig. 556

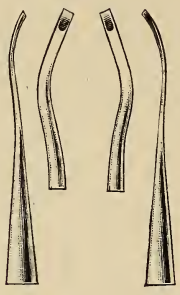


4 5 6 7 8

Tompkin's pyorrhea scalers.

For the preliminary breaking up of calcareous deposits the writer has devised a form of scaler with a dentate cutting edge which serves a useful purpose in dislodging the thin scale-like tartar deposits upon tooth roots (Fig. 558). The dentate edges of these instruments will break up such a deposit often when a smooth-edged instrument will fail to penetrate it. The dentate scaler should be followed by the use of a smooth-edged instrument to remove any adhering small particles of concretion and to give to the root a smooth surface.

Fig. 557



7 8

Adair's scalers.

Fig. 558



2 6

Kirk's dentate scalers.

Besides the difficulty of access and the obscurity of location which ordinarily prevents the use of direct vision as an aid in determining the position of calcareous deposits on the roots of teeth, the operation of

scaling for the removal of subgingival tartar is complicated by the slight hemorrhage incidental to the operation, and not infrequently by the pain which attends it. Various means may be employed to control both of these conditions.

Asepsis.—It is as important here as in any other surgical operation that the principle of asepsis should be applied and practically utilized, and while it is not possible under the conditions presented to secure a sterile field of operation, it is quite possible to greatly diminish the bacterial content of the mouth and to largely eliminate the sources of infection from the field of operation.

Preparatory Details.—In undertaking the scaling operation in a typical pyorrhea case it is assumed that it is for a patient who gives average attention to the details of the daily dental toilet, and that the teeth, as a whole, are therefore reasonably free from fermenting deposits or putrefactive debris. If the teeth are, however, not in a reasonably clean state, and show evidences of carelessness or neglect as to ordinary oral cleanliness, the necessary instructions as to thorough cleansing with brush and dentrifices should be given and the case dismissed until a later sitting, when these instructions shall have been carried out. When the case again presents, the field of operation should be protected from saliva by a properly adjusted napkin, then dried with spongoid, cotton, or bibulous paper, followed by a continuous blast of warm air at about 110° or 115° F., and painted with official tincture of iodin U. S. P., which contains 7 per cent. iodin. The gums and teeth should be well stained with the iodin, which cannot be satisfactorily done in the presence of moisture, and as the whole denture cannot, under the circumstances, be dried at once, the drying and coating with iodin must be done over a convenient area at one time and the operation repeated over a new area until all of the involved teeth have been so treated. The action of the iodin is threefold—it is an efficient germicide and antiseptic, it is slightly astringent, and in the strength prescribed it is a stimulant to the vascular supply and cell activity of the disordered tissues. After the iodin application, all visible deposits of salivary tartar should be removed and the teeth polished with fine pumice. Attention should next be directed to the subgingival deposits and concretions upon the roots.

Removal of the Deposits.—The operation of scaling and cleansing the teeth has thus far been considered from the standpoint of the denture as a whole. It is now of vital importance to the success of the operation that the operator concentrate his attention exclusively upon the individual tooth under treatment, and that he devote his time and his manipula-

tion to that particular tooth until he is convinced that its root or roots are free from deposits of whatever character before proceeding to treat the next. The operation must be thorough and the removal of deposits complete; the ideal should be to remove the *last* particle of tartar, that which is in contact with the marginal attachment of the pericementum; all those particles which precede the last one are of relatively minor importance, for if the last one be allowed to remain, the whole operation results in failure. Patient, persistent thoroughness, a cultivated touch, and educated skill are all requisites for success in this phase of the treatment.

Control of Hemorrhage.—During the course of the operation often the flow of blood will so obscure the field that at times it may become an annoying interference with further progress. A certain amount of hemorrhage in the early stages of the work may be deemed beneficial, as it relieves the engorgement of the gingival tissues usually present in these cases, for which reason the flow of blood may for a time be properly encouraged by a stream of warm water slightly above body temperature. Ordinarily the flow of blood will decrease when the tissues have thus relieved themselves of their abnormal engorgement, but if it persists to an annoying extent it may be reduced or even completely arrested by a stream of water as hot as can be borne by the tissues thrown against them from a syringe, or concentrated hydrogen dioxid (10 per cent.) touched to the pockets or bleeding surface is an efficient hemostatic. The hemorrhage may be positively controlled by an application of trichloracetic acid (10 per cent.) applied to the bleeding surface. Stronger concentrations should not be used, as they have a destructive action upon the soft tissues. A most useful adjunct in the treatment of pyorrhea cases for the control of oozing of blood or serum into the pocket, for cleansing the pocket from debris and rendering it patulous, so that from time to time a direct view of the root and interior of the pocket may be obtained in favorable situations, is the forcible injection of heated air under high pressure, as first suggested and advocated by Dr. H. C. Register, of Philadelphia.[1]

Control of Pain.—The margin of the pericementum when irritated and inflamed by contact with subgingival tartar is often exquisitely sensitive, a condition which in nervous patients prevents that passive submission to the treatment necessary to the performance of so delicate and difficult an operation. Under such circumstances, to relieve pain and secure passivity of the patient, it is advisable and proper to induce

[1] The Treatment of Dental Lesions by Compressed Warmed and Dried Air, H. C. Register, Dental Cosmos, vol. xxvii, p. 594.

local anesthesia of the gingival and pericemental margins. This can usually be accomplished by means of the topical application of a concentrated cocain hydrochlorid solution. A twist of cotton is saturated with the solution and packed with a suitable instrument under the gum and allowed to remain *in situ* for a few minutes. The region should be made dry previously to the application, and it will then usually be found that the sensitiveness has disappeared. If the topical application should fail to relieve the hypersensitiveness, then resort may be had to a subgingival injection of a 1 per cent. cocain or 2 per cent. novocain local anesthetic solution in the same manner and under the same precautions as are necessary in the induction of local anesthesia for tooth extraction. (See Chapter XVIII.)

Chemical Aids to the Scaling Operation.—The resistive texture of subgingival tartar deposits and their firm adherence to the root surface has led to the use of acid solvents as an aid to disintegrating the refractory deposits by chemical means. Dilute sulfuric acid (*acidum sulphuricum dilutum* U. S. P., 10 per cent. H_2SO_4), or the official aromatic sulfuric acid (*acidum sulphuricum aromaticum*), containing 20 per cent. of absolute H_2SO_4, has been highly recommended, especially by Professor James Truman, not only as a means for chemically loosening tartar deposits upon the roots of teeth, but also for its value in disintegrating the necrotic alveolar margins and stimulating the subjacent vital tissues to healthy reparative action.

Strong lactic acid has been extensively used for the same purpose and for the same general reasons; it has the advantage of higher solvent power for tricalcic phosphate, which it dissolves without leaving a residue; sulfuric acid, on the contrary, converts the tricalcic phosphate into calcium sulfate, setting free the phosphoric acid, and unless the sulfuric acid be sufficiently dilute, its action tends to be superficial and self-limiting, owing to the formation of a protective layer of calcium sulfate upon the surface of the tartar nodule. The self-limiting action of strong sulfuric action upon dentin is well shown in Calahan's method of root canal treatment

Trichloracetic acid also aids in the disintegration of deposits of tartar on roots of teeth, but both trichloracetic acid and lactic acid are coagulators of mucin, and their action upon the mucinous binding element of the tartar deposit tends to inhibit their otherwise useful solvent action upon the earthy mineral constituent of the tartar.

In a paper on "A Tartar Solvent Especially Useful in Pyorrhea Work,"[1] Dr. Joseph Head reported an investigation which he had made

[1] Transactions National Dental Association, 1899, p. 131.

of the action of acid ammonium fluorid as a solvent of tartar deposits, and announced as the result of his studies that a solution of the salt in question possessed the remarkable property of disintegrating tartar deposits, while it was without action upon tooth structure. The preparation of the inventor is sold in the depots under the proprietary name of "Tartasol." Reports as to its efficiency on the whole support the claims made for it, although a few cases of undue escharotic action from its use have been reported, and its application is generally reported to be painful. While any acid compound of hydrofluoric acid should be used with caution in contact with living tissues because of the well-known destructive action of hydrofluoric acid, the preparation in question, if its free acid is sufficiently neutralized to control its escharotic effect, should be a valuable adjunct to pyorrheal treatment not only because of its professed action as a tartar solvent, but more particularly because of the well-known germicidal action of the fluorin compounds with the alkali bases.

After-treatment.—When the teeth and exposed root surfaces have been freed of all deposits of extraneous matter of whatever nature by appropriate operative means, the retentive and surrounding tissues usually require further treatment to bring about a return to normal conditions. The principles governing the treatment relate to restoration of disordered circulation in the involved tissues, reëstablishment of their normal tone, and the prevention of reinfection, to accomplish which, local astringent, stimulant, and antiseptic applications should be judiciously made; massage of the gum tissue may be employed, and the daily use of an appropriate lotion by the patient, together with the most scrupulous attention to the details of the dental toilet, should be insisted upon.

As a local application which is stimulant, germicidal, and astringent, to immediately follow the conclusion of operative treatment of the teeth, the iodoglycerol of Talbot is of much value. It consists of a solution in which the germicidal properties of iodin are reinforced by the astringent and antiseptic properties of zinc iodid. The formula is as follows:

Zinc iodid	15 parts
Water	10 "
Iodin	25 "
Glycerin	50 "

An analogous combination, more complicated in its mode of preparation but essentially the same in therapeutic efficiency, although less liable to exert an escharotic effect for the reason that it is not so con-

centrated, is W. J. Younger's preparation, which is made as follows: Mix equal parts of No. 1, a saturated aqueous solution of zinc sulfate, and No. 2, a saturated solution of iodin in a solution of potassium iodid, 1 ounce; water, 4 ounces. The reaction of the potassium iodid with the zinc sulfate in Younger's formula results in the formation of zinc iodid and potassium sulfate, which latter salt in time crystallizes out, leaving a supernatant solution of zinc iodid and iodin, which is the effective therapeutic combination of the preparation. Either of these solutions applied by means of an appropriately shaped orange-wood point, or upon asbestos fiber wrapped around an aluminum wire applicator, will render the surface of the tissue impregnable to bacterial invasion and destroy infection to a considerable depth in the tissue; at the same time the astringent properties of the zinc iodid exert a stimulant and supporting effect, restoring tone to the capillary system. The topical application of these solutions should not be repeated oftener than twice or three times per week, as opportunity should be given for healthy tissue to form, which too frequently repeated treatment by such concentrated solutions of iodin and zinc iodid would tend to prevent. G. V. Black has recommended the treatment of pyorrheal pockets and necrotic areas with the following:

Oil of cassia	1 part
Phenol, cryst.	2 "
Oil of wintergreen	3 "

Campho-phenique has also been recommended for the same purpose.

James Truman strongly advocates the packing of pockets with quinin sulfate. Any mild antiseptic, stimulant, and astringent application which is sufficiently lasting when applied to the tissues in question will produce favorable results. The iodin and zinc iodid preparations of Talbot and Younger respectively have, in the experience of the writer, given more satisfactory results in the first phase of the local after-treatment of pyorrhea than any other medicament tried.

As a lotion for daily use by the patient nothing has yielded such definitely satisfactory results in the writer's experience as the following:

℞.—Zinci chloridi	ʒj
Aquæ menthæ piperitæ	fʒviij

Sig.—Apply to the gums on a cotton swab, t. i. d.[1]

[1] Zinc chlorid appears to have been first recommended for this use by the late Professor Charles J. Essig, who also suggested the use of dilute sulfuric acid as a means for softening and disintegrating refractory tartar deposits upon tooth roots. See an important paper on Some of the Causes of Loss of the Teeth in the Adult, by Charles J. Essig, M.D., D.D.S., Dental Cosmos, 1880, vol. xxii, p. 130.

The patient should be directed to avoid swallowing any of the lotion, and the application should be made after the teeth have been cleansed by brushing following the regular meals.

The prognosis is favorable in cases where the essential predisposing cause of the pyorrhea is tartar of salivary origin or tartar, mucoid and salivary, girdling the tooth below the anatomical neck acting traumatically.

PYORRHEA HAVING A CONSTITUTIONAL PREDISPOSITION

Loss of the teeth by a necrotic inflammatory process involving their retentive structures and wholly without the intervention of tartar deposits as a factor in the process is a common phenomenon well established by observation and experience. It is equally well established that loss of the teeth in these cases is generally associated with other objective phenomena indicating aberrations of various kinds from the normal standards of bodily health. The nutritional fault may be so slight as to escape casual notice, or may even be unrecognized by the patient; or, on the other hand, the destructive action going on in the retentive structures of the teeth may be definitely concurrent with a clearly defined and well-recognized bodily disease. The association of tabes dorsalis, leukemia, syphilis, arthritism, diabetes mellitus, various forms of nephritis, tuberculosis, etc., and the prolonged malnutrition often following typhoid, pneumonia, malaria, and other types of acute infection are matters of observation and record by both physicians and dentists. So also disorders which have their origin in defects of the nutritional mechanism; the diseases of metabolism, so called, are more or less constantly associated with pyorrheal disease of the dental retentive tissues, especially when the individuals so affected are well advanced in adult life, and not infrequently at an earlier period if the nutritional fault is pronounced and chronic. The disease may attack a single tooth or several at one time, or in comparatively rare instances the teeth of the entire denture may be simultaneously involved.

Tartar deposits may or may not be present, and if present, may have no direct causal relation to the destructive inflammatory action. On the other hand, certain calcareous deposits found upon tooth roots of this class of pyorrheal cases are distinctly a result rather than the cause of the local inflammation.

The type of pyorrhea associated with constitutional or general nutritional disorders differs essentially in its clinical manifestations by

reason of the depth of the invasion of the retentive structures by the pathogenic bacteria which are the exciters of the inflammatory process under consideration. The localized gingivitis and subsequent pyorrheal condition caused by the impingement of salivary tartar upon the marginal gum tissue is superficial and ulcerative in type, while that due to deeper invasion of the retentive tissues by pathogenic organisms made possible by the lowered internal or vital resistance of the tissues from malnutrition or constitutional disease is characterized by deep pus-pocket formation or by the tendency to periodically form abscesses.

Numerous investigators have endeavored to isolate the specific organism which it has been assumed might be the exciter of this destructive process, and while the search thus far has yielded no definite results in so far as the discovery of a single specific organism as the cause of pyorrheal infection is concerned, the evidence thus far attained points strongly to the conclusion that the organism mainly concerned in the causation of the type of pyorrhea here under consideration is the pneumococcus,[1] which acts as the initial exciter of the inflammatory process, and that the reaction produced by that organism is supplemented by a secondary invasion of the infected region by the Streptococcus pyogenes and Staphylococcus pyogenes aureus and its congeners. In short, it appears to be a mixed infection in which the pneumococcus plays the role of leader in an attack which is followed by organisms of relatively less virulence.

The predilection of the peridental membrane to infection by the pneumococcus has been definitely noted and reported upon by numerous observers; indeed, the periosteum of the entire mandible has been, in several cases, found to be the seat of destructive inflammatory action set up by pneumoccocal infection alone, or associated with Staphylococcus pyogenes aureus, and in cases of general constitutional disease, where from the nutritional interference the natural defensive forces of the tissues are below their normal health standard, invasion of the pericementum by the pneumococcus, which is an almost constant inhabitant of the oral cavity, is prone to occur.[2]

The path of the infection is in all probability along the network of cells described by Black as the "glands of the peridental membrane" (see page 472), and who found in the microscopic examination of a

[1] It is recognized that reports of bacteriological studies of pyorrheal exudates by no means uniformly record the presence of the pneumococcus. It is regrettable that in many instances the methods employed and especially the composition of the culture media is not stated. By the methods stated at p. 511 the practical constancy of the pneumococcus in pyorrheal exudates has been determined.

[2] See under General Considerations, p. 469, a discussion of the principles involved in the relation of normal health status to defence against bacterial invasion.

tooth extracted from a patient suffering from "phagedenic pericementitis" (the type of pyorrheal inflammation here under consideration) "that some of the lymphatics near the gingival border of the membrane were in a state of suppuration." This condition followed the lymph chains in the direction of the apex of the root to a distance which the author says surprised him, "considering the very slight signs of the disease before the removal of the tooth, and seemed especially confined to these cells." He says, further: "This case hints quite strongly that these lymphatics are the seat of this very peculiar affection."[1] While further scientific study of this phase of the matter is needed to thoroughly classify the question of the part played by these structures described by Black as glands of the peridental membrane, as the pathways of bacterial invasion in pyorrheal disease, clinical observation tends to amply confirm the observations made on the case quoted that these so-called glands are the pathway through which the infection takes place.

Exception may be fairly taken to the designation of these structures as glands. From studies made by the writer, the assumption of their glandular character does not appear to be warranted. The cellular elements of which they are composed, their morphology, and their relation to the embryological development of the tooth germ and its related tissues point to the conclusion that the so-called lymphatics of the peridental membrane are remnants of the epithelial sheath of Hertwig,[2] which in the adult membrane constitute "rests" of epithelial debris having the characteristics of a degenerative tissue. Examples of embryonal resting cells are found in many other locations in the body, which under irritation are prone to take on morbid activity, and also by reason of their degenerate character and low resistance are under favorable conditions peculiarly liable to infection.

The appearance of the structures in question is clearly shown in Fig. 559.

The epithelial origin of these so-called "lymphatics" is by no means a recent belief as to their character and significance.

Magitot[3] first advanced the hypothesis that the epithelial layer forming the inner wall of cysts of the peridental membrane was derived from the wall of the dental follicle. Malassez[4] confirmed and further

[1] Periosteum and Peridental Membrane, p. 93.

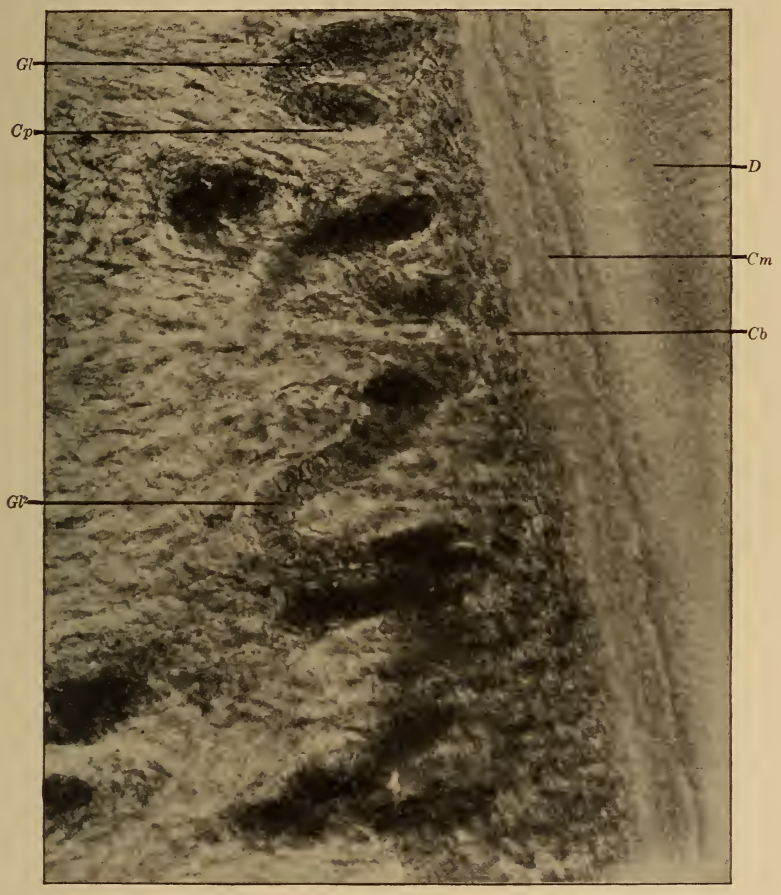
[2] Ueber das Zahnsystem der Amphibien, Archiv. für mikroskopische Anatomie, Supplementheft, 1874.

[3] Mémoire sur les Kystes des Mâchoires, Arch. génér. de Médecine, 1872, tome ii, pp. 339–414 et 681–699; Mémoire, etc., 1873, tome i, pp. 154–174 et 437–486.

[4] Sur l'existence d'amas epithéliaux autour de la racine des dents chez l'homme adulte à l'état normal, Arch. de physiol., 1885, tome i, p. 129.

extended the view of Magitot, while von Brunn,[1] by a thorough and elaborate microscopic study of the embryological development of the dental follicle, furnished the anatomical and histological data upon which a rational understanding of the process by which the epithelial structures

FIG. 559



Reproduced from Fibers of the Peridental Membrane. G. V. Black, Dental Cosmos, vol. xli, p. 111. Glands of peridental membrane shown with $\frac{1}{12}$-inch lens, in which the characters of the cellular elements appear. *D*, dentin; *Cm*, cementum; *Cb*, cementoblasts; *Gl* and *Gl²*, loops of glands in focus showing the cells; *Cp*, hyaline capsule enclosing gland, which also appears about *Gl²*.

found in the peridental membrane are derived from the embryonal epithelial cells that originate the enamel organ and are further extended upon the tooth root, through the peridental membrane, to and inclusive of the root apex in the adult. Concerning this extension of epithelial

[1] Ueber die Ausdehnung des Schmelzorgans und seine Bedeutung für die Zahnbildung, Arch. f. mikr. Anatomie, Band xxix, 1887.

cells, von Brunn's conclusion as stated by Dr. Witzel[1] is as follows: "The enamel organ extends not only as far as enamel is subsequently formed, but proliferates beyond the limiting border of the enamel and gradually covers the entire tooth germ up to the apex of the tooth." This proliferation of the enamel organ had already been described by O. Hertwig,[2] and v. Brunn adopted Hertwig's term epithelial sheath for this sheath-like epithelial process.

Infection of the epithelial nests distributed as a network throughout the structure of the pericemental membrane leads to inflammatory reaction not only of the membrane itself, but of the bony alveolar walls and the bone of the alveolar border, and the gingival tissue as well, resulting in a series of pathological and morphological changes in these structures characteristic of the destructive disorder, and ending in the loss by exfoliation of the involved teeth.

With loss of the teeth the disease is arrested, for the reason that the tissue in which the infection originates, viz., the peridental membrane, no longer exists as a factor in the process. For the same reason extraction and replantation of pyorrhetic teeth will effect a cure of the disorders in connection with teeth so treated, the peridental membrane being functionally destroyed by the operation, union of the replanted tooth to its alveolus being brought about by ankylosis. Similarly, destruction of the peridental membrane and irritation of the socket walls by the excessive use of scalers results favorably to the cure of the disease by eliminating to a greater or less degree the peridental membrane as a factor and reëstablishing union between the socket and tooth root by bony encapsulation or ankylosis.

The exact nature of the destructive action of the disease upon the bony tissue of the alveolar sockets has not as yet been definitely made out.

A. Hopewell-Smith[3] is of the opinion, based upon careful microscopic study of the diseased tissues, that "The disease of the bone is not in its earlier stages a rarefying osteitis. . . It is essentially dependent upon an osseous lesion, an *atrophy of the bone* which in the thinnest parts causes the cervical margins of the teeth to become denuded through the halisteresis (osteomalacia) and osteoclastic absorption. The presence of serumal calculus is not sufficient in itself to induce the condition, and may not be associated with it at all as a predisposing or

[1] Ueber Zahnwurzelcysten deren Entstehung, Ursache und Behandlung, Leipzig, 1896, p. 10.
[2] Ueber das Zahnsystem der Amphibien, Arch. f. mikr. Anatomie, Supplementheft, 1874.
[3] Dental Cosmos, vol. liii, p. 409.

exciting cause." The osteoclastic destruction of the alveolar bone is not infrequently extended to the pericementum, producing clearly marked evidence of root absorption about the apical extremities of teeth lost through pyorrheal disease.

FIG. 560



Vertical section through canine and right maxilla of man, aged twenty-eight years, showing latest stages of extremely acute conditions associated with pyorrhea alveolaris. Lateral section (×35). *A*, apex of root formed by hyperplasia cementum; *B*, hyperplastic peridental membrane; *C*, indifferent tissue enormously increased in amount and more vascular than usual; *D*, soft medullary tissue exhibiting signs of hyperplasia; *E*, large osteoparotic space; *F*, sequestrum of bone undergoing peripheral absorption; *G*, osteoclasts producing lacunæ absorption of the bone of the socket; *H*, bone of socket partially destroyed and converted into osteoid tissue; *I*, line of junction of decalcified and normal bone. Preparation and photomicrograph by A. Hopewell-Smith.

The alterations of histological structure in the tissues involved in pyorrhea alveolaris are shown in Fig. 560, reproduced from a photomicrograph of a section through the tooth root and its retentive tissues by A. Hopewell-Smith.

Destructive inflammatory lesions of the gingival and alveolar tissues, more or less simulating pyorrhea alveolaris, occasionally occur, due to specific infections; for example, syphilitic invasion of the gingival margins, or infections following the use of mercury as an antisyphilitic remedy.[1] The clinical history and the atypical appearance of these lesions will, however, furnish the data necessary to a clear differential diagnosis. A form of destructive gingival and alveolar inflammation, which may be mistaken for an acute expression of ordinary pyorrhea alveolaris of a phagedenic type is that produced by an invasion of the Bacillus fusiformis and spirochete of Vincent's angina. The history of the case will show that the inflammatory attack is essentially acute in character and differs from ordinary pyorrhea alveolaris in that the disorder promptly yields to local applications of iodin following curettement and hot water irrigations of the necrotic alveolar margins. In a doubtful case, bacteriological examination of the exudate will clear up the diagnosis.

Finally, scorbutus,[2] both in the adult and as occurring in improperly fed children, produces a marginal gum and alveolar lesion which in certain stages closely simulates pyorrheal disease of the alveolar border. The history of the attack and an examination of the food habit, together with the existence of the other lesions typical of scorbutus, *e. g.*, hemorrhagic infarcts of the skin simulating purpura hæmorrhagica, soreness of the articulating ends of the long bones, and, in children, motor paralysis enuresis, etc., will determine the nature of the constitutional disorder responsible for the mouth lesion and indicate the therapeutic procedures necessary for the correction of the disorder.

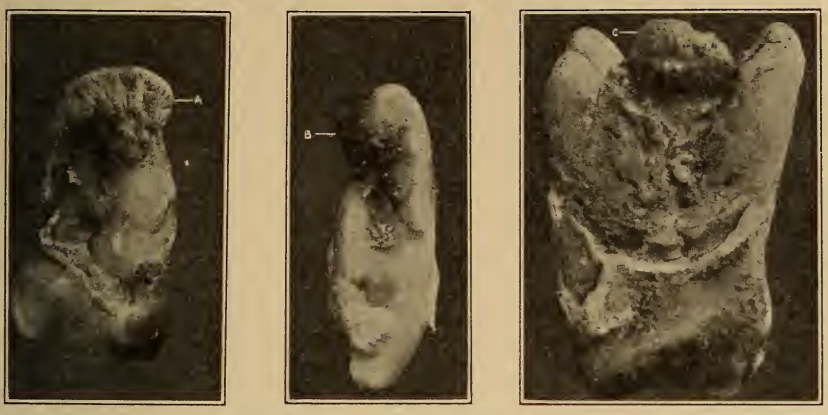
The deep invasion of the peridental membrane by pathogenic organisms in cases where the defensive agencies of the body are below normal frequently leads to the production of abscesses which are extremely painful, causing much distress to the patient during the period of their development, which ordinarily run a course of from a week to ten days, although in certain situations they may run a shorter course. The pus exudate may burrow its way between the cementum and the alveolar wall to the gum margin, in which case the so-called pus pocket, or pyorrheal pocket, is formed as the fistulous outlet; or when the focus of infection is located near the root apex in the case of a tooth so situated that the line of tissue resistance between the focus of infection and the gum margin is greater than that between the focus of infection and the

[1] See A. Loup, Considerations on the Role of Mercury in Mercurial Stomatitis, Dental Cosmos, 1900, xlii, 1300.

[2] Kirk, E. C., Two Cases of Infantile Scorbutus, Dental Cosmos, xxxvii, 1895, 489, and discussion, pp. 503 to 511.

overlying gum surface, then the fistulous outlet takes place upon the free gum surface, and the case becomes one of so-called abscess upon a tooth with a vital pulp, or, as designated by Dr. D. D. Smith, a pericemental abscess.[1]

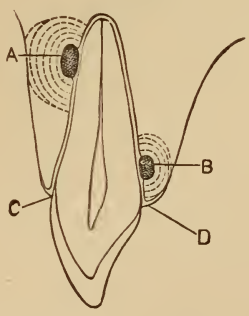
FIG. 561 FIG. 562 FIG. 563



Specimens showing pericemental abscess at *A*, *B*, and *C* respectively.

Fig. 564 will indicate diagrammatically the relation of the locus of infection to the resistance of the surrounding tissue in determining the part of the fistulous outlet. *A* represents an inflammatory focus near the root apex with fistulous outlet upon the free gum surface. *B*, a similar inflammatory focus near the anatomical neck of the tooth with fistulous outlet at the gingival margin *D*. The etiology and pathology of both lesions is the same; they differ clinically by reason of the location of the point of fistulous discharge due to location of the initial lesion. In the case of the lesion *A*, the fistulous outlet would have occurred at the gingival margin *C* had the part of resistance toward *C* been less than toward the gum surface over *A*.

FIG. 564



Much confusion as to the pathological significance of these abscesses has arisen by reason of the fact that they occur upon teeth with vital pulps. Their relation to pyorrhea alveolaris is, however, perfectly clear, and the clinical phenomena which they manifest are due solely to the depth of the bacterial invasion which is the exciter of the suppurative process, this deep invasion leading ultimately to a fistulous outlet upon

[1] D. D. Smith, Pericemental Abscess, Dental Cosmos, 1897, xxxix, 569.

the gum surface instead of at the gum margin, with pocket formation, as ordinarily occurs where the invasion is of less depth.

Bacteriological examination of the pus taken from a limited number of cases of pericemental abscess showed pneumococci and staphylococci as the principal organisms, and these may be regarded as the exciters of the inflammatory process. The pericemental abscess is typical of that form of pyorrhea alveolaris associated with a constitutional predisposition or systemic fault due either to bodily disease or to nutritional or metabolic error, which has reduced the defensive agencies of the body below normal and thus rendered deep invasion of the retentive tissues by pathogenic bacteria possible.[1]

Pyorrhea alveolaris may constitute a cause of malnutrition, or it may be a result of malnutrition. Infection of the gingival and alveolar tissues by pyogenic and other pathogenic organisms, besides leading to the inflammatory destruction of the involved tissues, coincidently leads to the production of toxic end products of bacterial activity, which, taken into the circulatory system, either directly from the seat of infection or *via* the digestive tract, set up a chronic toxemia of greater or less intensity which in time may lead to pronounced disturbances of health, both local and general, and not infrequently to metastatic infections, causing grave disease manifestations in various tissues and organs of the body. For which reason, thorough and systematic treatment, directed toward the correction of the local pyorrheal disorder, should be persistently carried on until the disease is under control.[2] On the other hand, certain forms of pyorrhea alveolaris are distinctly local expressions of faulty nutrition, and particularly of that type which in its collective or general expression is designated the arthritic diathesis or gouty diathesis, characterized by a subnormal oxidizing power and in which the pathological manifestations are of the class known as diseases of suboxidation. Cases of this class present a form of general malnutrition in which the metabolic mechanism appears to be incapable of completely converting proteid materal into its normal physiological end products, with the result that the whole of the excess

[1] For a fuller discussion of pericemental abscess consult the following:
Magitot, E. Mémoires sur les tumeurs périoste dentaire et sur l'ostéo-périostite alvéolo-dentaire, Paris, 1873.
Essig, Chas. J. Some Causes of Loss of the Teeth in the Adult, Dental Cosmos, 1880, xxii, 130.
Darby, Edwin T. Proc. Odontological Society of Pennsylvania, February, 1880, in Dental Cosmos, 1880, xxii, 248.
Kirk, Edward C. Abscess upon Teeth with Living Pulps, Dental Cosmos, 1898, xl, 621; Pericemental Abscess, Dental Cosmos, 1900, xlii, 1149.

[2] See Oral Sepsis as a Cause of Septic Gastritis, Toxic Neuritis, and Other Septic Conditions, by Dr. Wm. Hunter, Physician to St. George's Hospital, London. London and New York, Cassell & Co., 1901.

nitrogen, instead of leaving the body as urea, a soluble bland and non-irritating waste product, is partially retained and deposited in various of the tissues as members of the purin group and allied relatively insoluble compounds, which in certain positions become sources of chemical and mechanical irritation leading to cell death, so-called necrobiosis of tissue elements, and by thus establishing areas or loci of diminished resistance become the forerunners of local infections.

Chemical and microscopic examination of the tartar deposits upon tooth roots from patients of the class under consideration has amply demonstrated the presence of urates as the nucleus around which the deposit of calcic phosphate has taken place, thus confirming the arthritic origin of the lesion, which in its pathological character is strictly the analogue of the tophus of true gout.

Pyorrheal lesions of the arthritic type are relatively deep-seated, and less inclined to be marginal in their expression. The case presents a history of soreness and lameness and increasing looseness of the teeth, with but little or no visible pus formation. Atrophic changes in the alveolar walls become progressively manifest, and from time to time local tumefactions and swellings, indicating pus formation, occur over the roots of the more noticeably affected teeth. These acute localized inflammatory tumefactions may or may not develop into abscess formations.

In the earlier stages of these localized lesions the inflammation frequently subsides without discharge of the pus exudate, but later the swelling recurs, and in due course a minute abscess discharges its exudate upon the free gum surface, after which resolution or healing of the inflamed area takes place, to be repeated later, with more extensive involvement, until the tooth is finally lost.

Teeth extracted after having passed through the cycle of inflammatory phenomena here described will frequently show upon some portion of the root near the apex tartar formations even though there may have been no break of continuity in the attachment of the peridental membrane and gum tissue at the anatomical neck of the tooth. The tartar deposits in such cases are, therefore, unquestionably not salivary in origin, but are derived from the liquor sanguinis, and are properly designated as serumal or sanguinary tartar. Their mode of formation is explainable upon the same basis as the calcic formations that are found in old abscess cavities in other tissues of the body, notably in the lung, lymphatic glands, etc. Chemical and microscopic examination of these concretions in connection with the clinical history of the cases

of pyorrhea alveolaris, in which they occur, throws considerable light upon the method of their formation. It is a well-established physiological fact that a tissue, such as muscle or ligamentous tissue, doing active work rapidly undergoes metabolic changes while in action, and that in consequence of the increased oxidation involved, the reaction of the tissue tends toward acidity or relatively lessened alkalinity. Under these circumstances an area of lessened alkalinity in the tissues of an arthritic individual whose blood stream is carrying dissolved urates to the saturation point becomes a nidus in which precipitation of urates takes place. Irregular position of a tooth, or habit of the individual, will subject a given tooth to more than its physiological share of the burden of work in mastication, and thus make it the point of selection for a uratic deposit by developing, through overwork of a particular tooth, an area of decreased alkalinity in its investing peridental membrane and thus make it the point of selection or determination of the pyorrheal attack, just as the articulation of the distal phalanx of the great toe, from the relative prominence of its part in walking, becomes the point of selection for a localized acute inflammatory manifestation in classic gout. Deposition of urates in the selected area is followed by localized cell irritation and limited cell death, and the disturbed area constitutes a *locus minoris resistentiæ* in which infection takes place and the suppurative phenomena already described follow. Where resolution takes place in one of these areas without formation of fistula, caseation by dehydration of the retained abscess debris takes place, and final infiltration of the mass by calcic salts occurs by reason of the fact that the mass is now alkaline in reaction, due to the pus formation, and the final result is a tartar nodule having a nucleus of uratic salts around which has been deposited a mass of tricalcic phosphate bound together by the organic residue of the pus exudate.

The close relationship of arthritic malnutrition to pyorrheal involvement of the retentive tissues of the teeth is now clearly recognized, and the constitutional predisposition induced by arthritism to bacterial invasion is found to be dependent upon a diminished tissue resistance with lowering of the opsonic index, which in many cases is amenable to autogenous vaccine therapy, under which treatment the opsonic index has been raised to normal with cure of the local lesion.[1]

While arthritic individuals, especially those whose dietary is over-

[1] See The Association of Disease of the Mouth, with Rheumatoid Arthritis and other Forms of Rheumatism, Hunterian Lecture, by Kenneth W. Goodby, Lancet, March 11, 1911, p. 639; also Arthritism, by E. C. Kirk, Dental Cosmos, July, 1909.

balanced on the proteid side, represent a type of malnutrition which renders them especially liable to infection of the alveolar tissues by pyogenic organisms, it may be stated, as a broad principle, that any nutritional disorder which results in depression of the natural defensive agencies of the body, when sufficiently prolonged, is liable to become a predisposing cause of pyorrhea alveolaris. Rhein[1] has directed attention to this relationship of constitutional predisposition arising out of various systemic diseases, and has suggested a basis of classification of pyorrheal lesions as related to their etiology in that connection.[2]

Nutritional disturbance from neuroses, hereditary predisposition, and developmental errors have been shown by Talbot[3] to act as etiological factors leading to pyorrheal infection of the alveolar structures.

TREATMENT OF ALVEOLAR PYORRHEAL INFECTIONS HAVING A SYSTEMIC PREDISPOSITION

It is a fundamental axiom of therapeutics that the cure of a disease must involve the removal of its cause. As the cure of suppurative inflammatory lesions of the retentive structures of the teeth due to the impingement of tartar as a traumatic predisposing cause necessarily involves the thorough removal of tartar deposits as a prerequisite to successful local treatment of the inflammatory lesion, so also in pyorrhea alveolaris, due to constitutional malnutrition, treatment of the local lesion is without permanent curative effect until the underlying systemic fault has been effectually corrected. The mere routine local treatment by scaling and the application of antiseptic, stimulant, escharotic, or astringent drugs is of but temporary benefit; indeed, misdirected or ill-judged routine local treatment may do positive harm in cases of this class. A large proportion of pyorrheal cases having a constitutional predisposition, cases of the most intractable class have practically no tartar deposits whatever upon the tooth roots, and yet the empiric to whose mind tartar and pyorrhea are interchangeable terms, subjects such teeth to a vigorous application of the scaler to scrape the roots smooth even when no tartar is to be found upon them. Such ill-advised treatment wounds the gingival tissues, increases the

[1] Oral Expressions of Malnutrition, Dental Cosmos, 1896, xxxviii, 486; Pyorrhea Alveolaris, Dental Review, March, 1899.

[2] An Etiological Classification of Pyorrhea Alveolaris, Dental Cosmos, 1894, xxxvi, 779.

[3] See Interstitial Gingivitis or Pyorrhea Alveolaris, by Eugene S. Talbot, M.D., D.D.S., 1899.

opportunity for further infection, and lessens the already weakened resistive powers of the local tissue area involved. Careful exploration with a suitable delicately fashioned, exploring instrument should be made to first determine the presence or absence of tartar deposits before any attempt at scaling in these cases is made. Where tartar is not the obvious cause of the pyorrheal lesion, careful study of the character of the local gingival conditions should be made, the quantity and character of the pus flow should be noted, and the extent of atrophy or rarefaction of the alveolar borders determined. For the latter purpose the radiograph is a most valuable aid in diagnosis (Fig. 565). Where it is possible to do so, cultures from the exudate should be made and the nature of the infecting organisms determined. The history of the patient, the existence of systemic disease, or nutritional fault should be ascertained, and where doubt exists as to the nutritional or metabolic status of the patient, a careful urinary and salivary analysis should be made.

FIG. 565



Radiograph of the alveolar border of a patient suffering from pyorrhea alveolaris, in which the rarefaction of the bony tissue due to decalcification is clearly shown. Note also the resorption of the apex of the right canine root.

An almost unlimited number of antiseptic drugs have been suggested and tried for disinfecting the pus pockets and infected tissues in pyorrheal cases. Many are objectionable for the reason that they exert a destructive action upon the tissue cells as well as upon the invading pathogenic organisms. The ideal antiseptic is one that will exert a destructive effect upon the bacteria without injury to the tissue and at the same time have diffusive or penetrating power sufficient to enable it to reach the organisms deeply embedded in the infected tissues. Among the more recent remedies which have been favorably reported upon is bismuth subnitrate made into a paste with vaselin, the formula being Bismuth subnitrate, 33 per cent.; vaselin, 67 per cent.

This preparation injected by means of a warmed syringe into pockets and sinuses has been found to arrest pus formation markedly, and cures of alveolar pyorrhea are reported from its use.[1]

Another preparation which practical test has shown to have a marked value for the same use is silver iodid of 5 per cent. strength in an emulsion made with Irish moss (Chondrus). The preparation was first

[1] See Bismuth Paste as a Dental Therapeutic Agent, Rudolf Beck, D.D.S., Dental Review, 1909, xxiv, 1079.

employed in the treatment of urethritis in accordance with the following formula:

℞.—Argenti nitratis pulv.,
Potassii iodidi āā gr. lv
Aquæ dest. ℥vj
Mucilago chondri q. s. f℥iij

Dissolve the potassium iodid in all of the water and gradually add the silver nitrate in powder, shaking after each addition until all of the silver nitrate is dissolved, then add the mucilage and shake thoroughly. This method of compounding the emulsion is necessary in order to obtain the precipitate of silver iodid in an extremely finely divided state and keep it in suspension. The emulsion should be kept away from strong light.

For the application of medicaments to the infected pockets and sinuses in pyorrhea cases the device known as the "pyorrhea pen" is a most convenient and efficient means (Fig. 566). The instrument consists of a suitable handle in which is fixed a split metal holder, which by means of a rectangular sliding collar is made to grasp a pen-like double point of pyralin, the two leaves of which form a capillary space between them. The flexible points may be used either in single or double form, and because of the convex shape given to them by the clamping device, when dipped in the remedy a sufficient quantity is retained in the spoon-shaped depression and between the two points for application, without a surplus to overflow and spread upon surrounding healthy tissues.

A quantity of points is furnished with each instrument so that a new point may be used with each case. They may be altered in position with reference to the grasp of the holder, for greater convenience in reaching difficult cases, or altered in form by reshaping with scissors for special situations as needed.

In all cases where the progress of the disease has resulted in appreciable loosening of the teeth, the local treatment should be supplemented by some means for affording surgical rest to the teeth until reëstablishment of healthful condition of the tissues has rendered them firmer in their sockets and capable of withstanding the ordinary stress of mastication.

Fig. 566



The "Miller" pyorrhea pen.

A variety of means for splinting the loosened teeth have been suggested, and many ingenious mechanical appliances have been devised for that purpose. It is beyond the scope of this chapter to take up in detail the construction of these appliances, and for information upon that class of work the reader is referred to standard works on mechanical dentistry. A simple and effective device for securing surgical rest of pyorrhetic teeth during the stage of healing and recuperation of their alveolar structures consists in weaving a floss silk ligature about the disordered teeth so as to include one or more sound teeth at each end of the series of loose teeth, making several figure-of-eight turns of the ligature throughout the whole series, and then painting the ligature with a thick solution of celluloid in acetone, which rapidly hardens and makes an effective supporting splint that will not become loosened or deteriorate in many cases for two or three months. It should be understood that in placing the above described splint, the surfaces of the teeth, the ligature, etc., should be kept dry until thorough hardening of the celluloid solution has taken place. The drying of the solution may be hastened by applications of a warm air blast.

It is obviously without the sphere of the operative dental practitioner to undertake the treatment of the underlying constitutional aberrations that predispose to alveolar infections; it is, however, distinctly within his province to be able to recognize intelligently these mouth lesions as indications of general bodily disease or nutritional errors, and to be able not only to direct the patient to a physician for treatment, but also to aid in the diagnosis of the systemic fault by reason of his knowledge of the relationship of the various objective phenomena or symptoms presented by these alveolar lesions to the several systemic states with which they are connected. In order that the dentist may secure the training necessary to fit himself to diagnose correctly the nature of these alveolar lesions, it is essential that he coöperate with the physician and keep in touch with the medical treatment of the case, while the local dental treatment is being concurrently carried out. The knowledge gained from the medical study and treatment of the systemic condition will in due course enable the dental practitioner to determine from a study of the mouth lesion, the general and often the special nature of the constitutional fault which is the underlying predisposing factor in the case, and when armed with such knowledge, enable him also to point out often constitutional disorders in their earlier stages and before the patient has otherwise become aware of their existence.

The question of the curability of the type of pyorrheal disorder here under consideration is so frequently the subject of discussion, and its

solution depends so obviously upon the scope of meaning that may be attached to the term cure, that it is important to briefly and definitely consider the matter here.

Where the alveolar infection is consequent upon a lowered vital resistance of the infected tissues due to constitutional disease or general malnutrition, local treatment, while it may arrest the progress of the disorder temporarily or keep it under control for a variable period of time, cannot alone effect a cure in the sense that the tendency to a recurrence of the disorder is permanently eradicated. The permanent cure of this type of pyorrhea alveolaris necessitates the eradication of its predisposing constitutional cause just as the permanent cure of pyorrhea due to infection consequent upon tartar deposits necessitates the removal of the tartar as a predisposing cause. In either case, where the predisposing cause is constantly operative, local treatment alone, which is necessarily intermittent, will ultimately fail to effect a permanent cure. When both the predisposing cause, be it local or systemic, and the local infection can be eradicated, the disorder is unquestionably curable.

When the lowered resistance of the patient is mainly due to absorption of toxins, and when the resulting malnutrition is not due to specific constitutional disease, prompt and permanent restoration of the infected gingival tissues to health may be brought about by the judicious application of vaccine therapy. So satisfactory has this method of treatment proved in a fair proportion of otherwise intractable cases, that the following description of the method is here appended:

VACCINE THERAPY OF ORAL INFECTIONS[1]

In common with other local pathological conditions, brought about through the agency of bacteria, affecting various parts of the exterior and interior of the animal economy, certain infections of the oral cavity and its adnexa coming within the domain of the dental practitioner are amenable to the action of bacterial vaccines—not only those due primarily to the invasion of the tissues by pathogenic bacteria, but also conditions in which such organisms are present as secondary invaders of a pathological process originally due to some other deleterious agent. In the treatment of these conditions the mistake is, however, frequently made of depending entirely on the

[1] This addition to the chapter on Pyorrhea Alveolaris is contributed by Nathaniel Gildersleeve, M.D., Assistant in the Bacteriological Laboratory, University of Pennsylvania.

vaccines and instituting no other local or general therapeutic measures in combating the diseased conditions; if this procedure is adhered to the results of bacterical therapy will, in a large percentage of cases, be disappointing.

Manifestly, bacterial vaccines will not exert a curative action on factors other than bacterial, entering into a causative relationship to diseased conditions; inoculations will frequently eliminate the bacterial element and, in so far as the infective nature of the condition is concerned, bring about a marked improvement or cure; leaving, however, the predisposing factors unchanged and still capable of exerting an irritative action on the tissues, paving the way for a fresh infection to be grafted into the process. These points are of as much importance in connection with oral infections as with those occurring in other parts of the economy.

In considering the subject of vaccine treatment of oral infections there are certain principles which the operator should have firmly fixed in his mind, and from which he must not depart if satisfactory results are to be expected. The most important of these are as follows:

I. A thorough familiarity with all pathogenic organisms capable of causing infections in the oral cavity and surrounding tissues; with the different species concerned in the various types of infection and with all pathological conditions in which bacteria may be present as secondary invaders.

II. A knowledge of the types of infection, and the toxic substances produced by the various organisms, together with the various types of immunity active against each species. Such knowledge will prevent the operator employing a vaccine in attempting to combat the ravages of an organism against which these substances will not immunize.

III. Always become satisfied, by microscopic examination and cultural methods of the exact nature and identity of the organism or organisms concerned in the individual infection under treatment.

IV. Use vaccines known as autogenous, *i. e.*, vaccines prepared from the pathogenic organisms isolated from each case; and if more than one species is present, to which may be ascribed an etiological relationship to the condition, employ a mixed vaccine or, separately vaccines prepared from each organism. He should not depend on stock vaccines or treat any case empirically.

V. Exercise judgment and discretion as regards the dosage and interspacing of inoculations, watching the patient's condition carefully, and always be in a position to control the injections by determining and interpreting the opsonic index.

VI. Employ in conjunction with the vaccines other local and general therapeutic measures capable of exerting a curative influence on the process, removing, as completely as possible, all sources of irritation.

VII. Always take into consideration the patient's general condition. There are frequently underlying systemic factors lowering the resistance of the tissues, thus paving the way for local infections.

For methods of isolating and identifying the various organisms, the reader is referred to one or another of the works on the subject of bacteriology, as an attempt to enter into a detailed description of such methods would involve the writing of a text-book on the subject. A few points of importance regarding plating media for the isolation of bacteria from the oral cavity had perhaps best be mentioned. There are organisms, playing an important part in infections, inhabiting the oral cavity which many fail to isolate, for the reason that suitable media are not employed. Notable among these is the pneumococcus. Milk agar, milk serum agar, blood serum agar, or blood agar should be employed routinely when dealing with bacteria of the oral cavity, and the cultures incubated at 37° C., under both ordinary and anaërobic conditions.

These media are readily prepared by keeping on hand, in tubes containing about 5 c.c., sterile milk, milk serum, and blood serum, and adding one or another of them to tubes of a 2 per cent. nutrient agar, after it has been liquified and cooled to 42° C., in the proportion of 1 part to 3 parts of the nutrient agar.

Preparation of Vaccines.—In the preparation of vaccines all apparatus, containers, and solutions employed must be sterile, and great care taken to prevent extraneous organisms from gaining access to the vaccines.

Several slant cultures are made on the surface of tubes of suitable media, from a freshly isolated pure culture of the organism, and incubated at 37° C. for from eighteen to twenty-four hours; the organisms are then washed from the surface of the media with 0.85 per cent. sodium chlorid solution and transferred to a sterile bottle or test-tube containing sterile glass pearls or a small amount of clean sterile sand. The container is now tightly stoppered or sealed and shaken, either by hand or in a mechanical shaker, for the purpose of breaking up clumps and producing a homogeneous distribution of the bacteria throughout the suspension. A small amount of the suspension is then removed and the number of bacteria per cubic centimeter estimated by counting with a Thoma-Zeiss hemocytometer, using a counting cell

of $\frac{1}{20}$ mm. depth; or by mixing, in a capillary pipette, equal parts of the bacterial suspension, 2 per cent. sodium citrate solution and blood obtained by puncturing the finger or lobe of the ear, this mixture is spread thinly on slides, fixed and stained by an appropriate method.

The number of bacteria and erythrocytes in 100 microscopic fields are counted with the aid of a $\frac{1}{12}$ oil immersion lens and the number of bacteria per cubic centimeter estimated by a mathematical deduction assuming that 1 c.c. of blood contains 5,000,000,000 erythrocytes.[1]

The suspension of bacteria is next placed in a tube, the end sealed, and the tube immersed in a water bath and heated, at approximately the lowest thermal death point of the organism, for a sufficient period to kill the bacteria. The suspension is then diluted to the desired strength,[2] with 0.85 per cent. sodium chlorid solution, 0.2 per cent. of phenol or tricresol added, subcultures made for the purpose of determining its sterility, and the vaccine, which we now call the bacterial suspension, pipetted into 1 c.c. ampoules, which are then sealed, making a closed container, which cannot become contaminated. The suspension is diluted to the extent that 1 c.c. of vaccine will contain the number of organisms constituting the proper maximum dose; when less than the maximum dose is desired, it can readily be measured by employing a graduated hypodermic syringe.

The Opsonins and Opsonic Index.—Metchnikoff demonstrated the phenomenon of phagocytosis, ascribing to the leukocytes, notably the polymorphonuclear, and certain other tissue cells, the function of

[1] Equation for estimating number of bacteria per cubic centimeter of suspension:
E : B : : E′ : X
E = number of erythrocytes per microscopic field.
B = number of bacteria per microscopic field.
E′ = number of erythrocytes per cubic centimeter of blood.
X = number of bacteria per cubic centimeter of suspension.
EXAMPLE: In 100 microscopic fields of slide there were counted 800 bacteria and 400 erythrocytes. The number of bacteria per field = 8 and of erythrocytes 4; 1 c.c. of blood contains 5,000,000,000 erythrocytes. The number of bacteria per cubic centimeter of suspension = 10,000,000,000.
4 : 8 : : 5,000,000,000 : X = 10,000,000,000.

[2] Formula for dilution of vaccine:
$\frac{S}{V} - 1 = Q.$
S = number of killed bacteria in suspension.
V = number of killed bacteria desired in vaccine.
Q = number of volumes of salt solution required to produce desired dilution.
EXAMPLE: Suspension contains 10,000,000,000 bacteria per cubic centimeter; a vaccine containing 250,000,000 is desired.
10,000,000,000 ÷ 250,000,000 = 40 — 1 = 39 volumes of salt solution to be added to 1 volume of suspension.

engulfing and digesting bacteria. He advanced the phagocytic theory of immunity.

This attracted the attention of scientists for a number of years, but was practically lost sight of by the majority following the promulgation of Ehrlich's theory; a few, however, still occupied themselves with researches on phagocytosis, and, among other facts, it was demonstrated that when the leukocytes were freed from serum they lost the function of phagocyting the majority of species of bacteria, but when serum was added this function again became manifest. This demonstrated the fact that serum was necessary for the phagocytic phenomenon, and it was claimed by some that serum stimulated the leukocytes to exert this function. It remained for Wright to demonstrate that when leukocytes washed in sodium-citrate-chlorid solution, for the purpose of freeing them from serum, were brought in association with bacteria that had previously been treated with serum, the phagocytic phenomenon again became manifest, thus proving conclusively that the serum element necessary for phagocytosis acted not, as was supposed, on the leukocytes, but upon the bacteria, preparing them for the engulfing function of the phagocytes. To these substances Wright gave the name of opsonins.

The opsinins may be defined as vital tissue elements, circulating in the body fluids, having the property of acting upon bacteria, so as to prepare them for phagocytosis. These elements exist normally in the tissues (normal opsonins), and act as one of the normal defences against the invasion of the tissues by bacteria; they are decreased by many factors exerting a deleterious influence on the normal metabolic processes of the economy, rendering the individual more susceptible to infection; they are likewise decreased in certain infections, and can be markedly increased by active immunization (immune opsonins) by means of the bacterial vaccines.

The fact must be borne in mind, that while immunity against certain species of bacteria is apparently wholly opsonic, in the case of other species it is not only opsonic, but there are other elements, as agglutinins, bacteriolysins, and antitoxins, exerting an antibacterial function; further, that there is no evidence of opsonic immunity in connection with protection against certain other species of bacteria. The opsonic index is the opsonizing power of a given serum as compared with that of one or more normal sera taken as a unit. This index guides the operator as regards the amount of vaccine to be employed as the initial dose, and the intrespacing and increasing of subsequent doses.

The greater the depression of the opsonins the smaller should be the

initial dose of vaccine, and the more carefully should the following doses be increased and interspaced.

To illustrate this, let us consider the phenomena presenting in a case of infection not only as it appears for treatment, but following the injection of vaccine. An index determination will show a greater or lesser depression of the opsonins toward the organism concerned in the infection; following the injection of a vaccine there appears after from six to twenty-four or forty-eight hours a further depression of the opsonins, which condition is termed the negative phase; later, if the dose has not been too large, or the resistance of the individual too low, we will find a rise in the opsonins to or above that exhibited before inoculation, this is termed the positive phase; a second inoculation should not be made until the establishment of this phase; when a second dose of vaccine will give rise to a less marked negative phase followed by a more pronounced positive phase; these phases present in order following subsequent inoculations until the index rises to or above normal, *i. e.*, when the opsonizing power of the patient's serum equals or exceeds that of the normal controls. The rapidity with which this condition is established depends on:

The Type of Infection; Degree of Depression of Opsonins; General Condition of the Patient and the Care Exercised as Regards the Dosage and Interspacing of the Vaccine.

FIG. 567

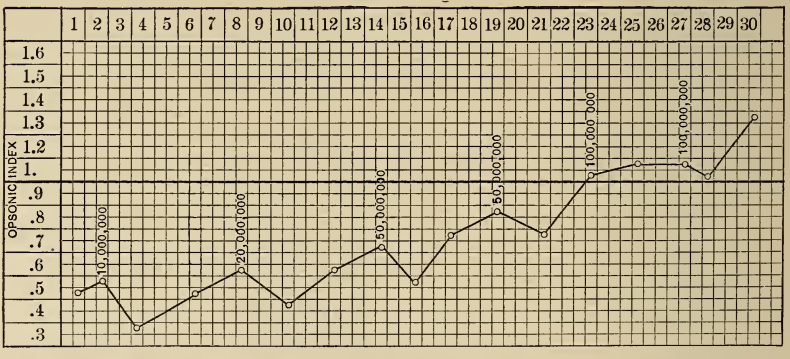


Chart showing effect of inoculations in a case of streptococcous infection of the nasal sinus. Note negative and positive phases following the injection of vaccine, beginning with 10,000,000 and increasing to 100,000,000. Circles indicate the index.

Technique of Determining the Opsonic Index.—Apparatus required: *An opsonizer:* This consists of a copper box, with two openings in the top, for a thermoregulator and a thermometer. Through this box are soldered horizontally brass tubes, $\frac{3}{8}$ inch inside diameter; the size

of opsonizer and number of tubes can be varied to suit the requirements of the operator. *A high-speed centrifuge*, fitted with small tubes for washing the blood and separating leukocytes. *A small mechanical shaker* will be found a very convenient part of the outfit. *Wright's capillary pipettes*, made of $\frac{3}{16}$ to $\frac{1}{4}$ inch glass tubing; pieces of the tubing about 6 inches long are heated in the middle by means of a Bunsen or blast flame and drawn out to a diameter of about $\frac{1}{32}$ inch; the distal end is fitted with a small rubber bulb. *Serum pipettes*, for collecting and separating the serum; these are about $2\frac{1}{2}$ inches long, of thin glass tubing, one end drawn out straight, the other drawn out and bent at an angle of 45 degrees. Other apparatus required include a microscope; microscope slides and cover-glasses; a blood stylet; sterile bottles, tubes, and glass pearls; sterile volumetric and capacity pipettes.

Reagents required include 0.85 per cent. sodium chlorid solution, a 1 per cent. sodium citrate solution in 0.85 per cent. sodium chlorid and suitable bacterial and blood stains.

Further, we require a bacterial emulsion, washed leukocytes, serum from patient; normal sera, preferably from three or four normal individuals; if the serum of but one healthy person is used it should be compared every few days with several other normal sera, and if more than a very slight variation is noted, the several sera employed.

The bacterial emulsion is prepared by cultivating the organism on suitable media for eighteen to twenty-four hours; washing it off with sterile salt solution; emulsifying in a sterile bottle or tube containing glass pearls; some bacteria are readily emulsified when shaken by hand, while others must be placed in a shaking apparatus, the latter procedure being preferable in all cases. After emulsifying and diluting the suspension, it is centrifugalized for one or two minutes, to remove any clumps that may remain. The density is then determined by opsonizing with normal serum to obtain its so-called phagocyting index, or by comparing it with a barium sulfate standard (McFarland's nephelometer), and then diluted to the proper strength; it is stated that it should be of such density that when opsonized with normal serum each leukocyte will ingest from five to eight of the ordinary bacteria. Some prefer a suspension of somewhat greater strength; the counts are more difficult, but the results are, it is claimed, more uniform.

Washed leukocytes are obtained by filling two of the small centrifuge tubes three-quarters full of citrate solution; then wrapping the finger with a rubber band, so as to cause congestion at the end, make a puncture with a stylet at the root of nail or side of finger, and allow the blood to fill the citrate tubes. It is then mixed by inverting tubes several

times, and centrifugalized; when the corpuscles are well packed and the supernatant fluid is clear, remove the solution carefully, so as not to disturb the corpuscles, fill with 0.85 per cent. sodium chlorid solution, and again centrifugalize. It is best to repeat the latter process twice to make sure that all of citrate and serum has been washed out; remove the salt solution carefully, to avoid disturbing the layer of leukocytes which will have collected on the surface of the sediment; the last drops are best removed by inclining the tube and inserting a capillary pipette at the upper part of the meniscus. The upper layer of sediment, containing the leukocytes, is removed with a clean capillary pipette and placed in a small sterile tube. This is then thoroughly mixed by drawing in and out of the pipette, being careful to avoid admixing air bubbles. This so-called leukocyte cream will contain with the leukocytes some erythrocytes. These appear to be advantageous, as better results are obtained when they are present than when leukocytes alone, the true leukocyte cream, are employed.

Serum is obtained by puncturing the finger, and allowing blood to flow into the curved end of the blood pipette until a sufficient quantity is obtained; the tube is then grasped lengthwise between the thumb and forefinger and the point of the straight end warmed and sealed in the flame. As the end of the tube cools the blood in the curved end is drawn into the body. The tube can be placed in the opsonizer or incubator for fifteen to twenty minutes, when the serum will usually be separated; if not, the tubes may be centrifugalized for a few moments. When the serum is required, the tubes may be notched on one side with a file and readily snapped off with the fingers or by touching with a hot glass point.

Method of Determining Index.—The opsonizer should be placed on a table to the right or left of the operator; sera, leukocyte cream, bacterial suspension, and all necessary apparatus in front; all within reach, as one must work quickly and accurately, and each tube be timed as it is placed in the opsonizer. A mark is made with a paraffin pencil on the capillary pipette, three-quarters of an inch from the end; the rubber bulb is connected and the mixture made by drawing substances into the tube in the following order: 1 volume of leukocytes, a bubble of air, 1 volume of bacterial suspension, a second bubble of air, 1 volume of serum—some add to this a second volume of leukocytes, varying the technique in this respect, with excellent results. The writer has found this of value especially when the stronger bacterial suspension is employed. The contents of the pipette is then emptied into the concavity of a concave slide and thoroughly mixed by drawing in and out of the pipette several times, care being taken to get rid of all air bubbles,

as this interferes to some extent with phagocytosis; the mixture is drawn into the pipette, the end sealed quickly, and placed in the opsonizer, where it is left for exactly fifteen minutes; some incubate for twenty minutes—this makes little or no difference. The important point to bear in mind is that all tubes, the preparations to be tested and controls, must be opsonized for the same length of time, as a matter of a few seconds frequently makes more difference in the results than one would imagine. The point of pipette is then broken off and the contents expressed on one end of two or three clean glass slides and spread evenly over the surface by placing the end of another slide in contact with the drop and drawing it over the first; this, if properly done, yields a thin even smear. Some employ a specially made spreader, but this will be found unnecessary, as one can make perfect smears with a little practice by using the end of an ordinary slide. The preparation is allowed to dry in the air, and stained with Wright's or some other blood-stain; if one should employ the ordinary aqueous staining solutions, the preparation must be first fixed by treating for a minute with methyl alcohol. The technique for staining is the same as for ordinary blood films with which anyone who will undertake the work is familiar.

The number of bacteria ingested by two hundred leukocytes are counted in each preparation, *i. e.*, those made with patient's and normal sera used as a unit. Some investigators pool the normal sera and make but one unit preparation; this is not a good practice, as the pooled sera preparations frequently vary quite markedly from those made with each serum separately. After counts are made, divide the number of bacteria ingested per leukocyte (phagocyting index) in the preparations made with patient's serum, by the number ingested per leukocyte in those made with the normal sera, which gives the opsonic index.

Many will meet difficulties in making these preparations. One great source of trouble to beginners is controlling the pipette so as to obtain exact amounts of each ingredient in making the mixture. Accuracy can only be attained by practice. The pipette can be handled best by grasping between the middle and third finger, and the bulb between the thumb and index finger.

Method of Making Inoculation.—After having decided on the dosage of vaccine to be employed, a 1 to 2 c.c. hypodermic syringe, having a glass barrel and fitted with a needle of comparatively small lumen, is carefully sterilized and filled with the vaccine. The skin over the site chosen for inoculation is cleansed with a 2 per cent. phenol solution, followed by sterile water and absolute alcohol, and the needle introduced into the subcutaneous tissue. The site of inoculation is preferably

just below the angle of the scapula, outer side of upper arm, the buttocks, thigh, or outer side of the leg.

The dose of vaccine to be given varies according to the organism employed; the degree of depression of index; the type of infection; age and physical condition of the patient. In many instances the dose employed has been too large and some of the poor results reported are undoubtedly due to this fact; it is always best to start with a small dose and increase. No absolute rules can be laid down regarding the size of the dose; in general it can be said that smaller doses should be employed when the index is very low than when moderately depressed; in general, if employed at all, than in local infections; in acute than in chronic conditions; in children and individuals markedly depressed and in poor condition than in adults and the more robust. The doses of the various vaccines that will commonly be employed in treating infections of the oral cavity range about as follows:

Micrococcus aureus and albus, 50,000,000, 100,000,000 to 600,000,000.

Streptococcus pyogenes, 10,000,000, 25,000,000 to 100,000,000.

Pneumococcus, 10,000,000, 25,000,000 to 100,000,000.

Micrococcus catarrhalis, 25,000,000, to 100,000,000.

Influenza bacillus, 25,000,000 to 100,000,000.

CHAPTER XVI

DISCOLORED TEETH AND THEIR TREATMENT

By EDWARD C. KIRK, D.D.S., Sc.D.

Discoloration of a tooth is a result of death of its pulp. While death of the pulp does not always or necessarily involve discoloration of the tooth structures, yet when the condition does exist the general cause is as stated. Reference is here made to a progressive interstitial staining of the entire dentin structure, and is exclusive of certain metallic stains, also of localized stains resulting from the imbibition of pigmentary matters occasionally observed where small areas of dentin have become denuded of enamel covering, or where the latter has been so imperfectly formed as to afford an insufficient barrier to the ingress of pigmentary matters from the food or oral secretions.

Three classes of conditions are presented for consideration and treatment: First, cases where discoloration has resulted from death of the pulp due to causes other than its exposure; second, discoloration from pulp death consequent upon exposure; and third, special discolorations due to adventitious causes superadded to the conditions affecting the cases included in the foregoing second division.

Any of the numerous traumatic causes which bring about death of the pulp, *e. g.*, blows, sudden contact with hard substances, biting threads, violent thermal shocks, the injudicious application of continuous force in regulating, or the application of arsenous oxid to the dentin, where no exposure or only minute exposure of the pulp exists, may produce hyperemia and congestion of the pulp, or strangulation of its circulatory system, the formation of emboli, thrombus, hemorrhagic infarct, etc., leading to a breaking down of the corpuscular elements of the blood, the escape of hemoglobin from the stroma of the red corpuscles, its solution in the blood plasma, and resulting infiltration of the tubular structure of the dentin by the hemoglobin solution, giving the tooth a distinctly pinkish hue when examined by direct or transillumination.

Suffusion of the dentin structure by discharged hemoglobin may be readily produced by the topical application to the exposed pulp of medicaments having a hemolytic property, for example, trinitroglycerin, glonoin, as an ingredient of a cocain solution intended for the production of local anesthesia, will not infrequently produce hemo-

lysis with suffusion of the dentin when the mixture is locally applied to a bleeding pulp. Even distilled water exerts a hemolytic effect, rupturing the stroma of erythrocytes by endosmosis; therefore, all solutions intended for topical application to a bleeding pulp should be at least isotonic with the plasma or preferably of greater density in order to avoid staining the dentin with diffused hemoglobin.

Teeth so affected rapidly change in color through various gradations in tint from the original pinkish hue, which becomes yellow; this, growing darker, passes into brown, and after the lapse of considerable time the tooth may become a permanent slaty gray or black.

The violence of the hyperemia preceding the death and disintegration of the pulp in a considerable degree determines the rapidity of the process of subsequent tooth discoloration. When congestion of the pulp has been relatively slight and the necrotic process has proceeded slowly, the sudden infiltration of the dentin with hemoglobin does not occur, consequently the initial change in color following complete death of the pulp may be so slight as to escape detection except upon most searching examination with special means of illumination, and even then may be manifested only by a slight diminution in the normal translucency of the tooth as compared with adjoining teeth. Such teeth, however, if permitted to remain untreated, eventually grow darker, and while they may not acquire a degree of discoloration equal to those which have suffered sudden and violent death of the pulp, still they become so unsightly as to demand treatment for the restoration of their normal color.

The Rationale of the Process of Discoloration.—In teeth discolored as a consequence of the death of the pulp without its exposure—viz., those of the first class—it is evident that the sources of pigmentation are internal to the tooth and are to be sought for solely in the products of decomposition of the elements of the pulp tissue and of its vascular supply.

The proteid elements of the pulp tissue are complex combinations of carbon, oxygen, hydrogen, nitrogen, sulfur, and phosphorus, which in their gradual breaking down by the process of putrefactive decomposition are split up finally into carbon dioxid, water, ammonia, and hydrogen sulfid, with possibly the formation of traces of phosphatic salts. The group of substances entering into the composition of the histological elements of pulp tissue contains no constituents which in the progressive changes resulting from putrefactive decomposition should form compounds likely to cause permanent discoloration of the tooth structures.

When, however, the vascular supply is considered as a factor, the explanation of the cause of discoloration in the cases in question becomes reasonably clear. The red blood corpuscles contain as their characteristic component hemoglobin or oxyhemoglobin according as the blood

is venous or arterial, and this substance is its essential coloring ingredient. When undergoing gradual decomposition, hemoglobin passes through a variety of alterations in its chemical constitution, accompanied by a corresponding series of color changes.

A familiar illustration of these color changes is furnished by the cycle of color alterations witnessed in a bruise. Immediately following an injury to the flesh, of the character alluded to, an extravasation of blood in the bruised territory occurs, causing undue reddening of the skin; this is soon followed by an increasing darkening of the tissue, until there results what is popularly termed a "black-and-blue spot." Further decomposition of the coloring matter of the extravasated blood induces a variety of color changes ranging through the scale of yellows and browns, until the pigmentary matter is finally removed by absorption through the capillary bloodvessel system of the part.

In passing through the cycle of color changes due to its progressive decomposition, hemoglobin undergoes several alterations in composition, among which are formed a number of definite compounds, each having marked chromogenic features. Of these decomposition products, methemoglobin (brownish red), hemin (bluish black), hematin (dark brown or bluish black), and hematoidin (orange), are the most important and best known. While the gradual decomposition of the coloring matter of the blood here noted may and doubtless does account for certain phases of tooth discoloration, other factors which exert a profoundly modifying influence upon the process are yet to be considered.

The putrefactive decomposition of the proteid elements of the pulp results, as before stated, in the production of hydrogen sulfid in considerable quantity. The albumins contain from 0.8 to 2.2 per cent. of sulfur (Hammersten), which in the splitting up of the compound during putrefaction yields a large amount of hydrogen sulfid. In pulp decomposition this hydrogen sulfid is generated in contact with the hemoglobin, and necessarily exerts a marked modifying action upon the decomposition process of that substance. Miller says: "If a current of hydrogen sulfid is conducted through fresh blood or a solution of oxyhemoglobin in the presence of air or oxygen, sulfomethemoglobin is formed, which is greenish red in concentrated solutions and green in dilute solutions. If we lay a freshly extracted tooth in a mixture of meat and saliva so that a part of the enamel surface remains free, and moisten the surface with blood, it will take on a dirty green color if kept at blood temperature in an absolutely moist condition for from twenty-four to forty-eight hours. It is quite possible that the dirty green deposits which form in putrid conditions of the mouth, in stomatitis mercurialis, scorbutica, gangrenosa, etc., or even in inflammatory conditions of less importance, as well as in cases of absolute neglect of the care of the mouth, may owe their green color to the presence of sulfomethemoglobin."

As in pulp decomposition hydrogen sulfid is being formed in the presence of hemoglobin, this fact warrants the belief that a combination takes place resulting in the formation of this same compound, which Miller regards as productive of certain stains upon the external surface of the teeth.

The slaty gray or bluish pigmentation always noticeable upon the visceral walls and frequently beneath the skin of animal bodies undergoing putrefactive decomposition is a familiar example of the action of hydrogen sulfid or its ammonia combinations upon decomposing hemoglobin in hemorrhagic extravasations, and is a process and form of pigmentation exactly analogous to that which is here described as taking place in the dentinal structure from putrefactive decomposition of the pulp. "When red corpuscles are just beginning to disintegrate, the coloring matter formed is hemoglobin; but the yellow and brown granular masses found in cells and lying free in tissues are, as a rule, derivatives of hemoglobin, not hemoglobin itself. These derivatives are divided into two groups according as they contain iron or not, the former being called hemosiderin, the latter hematoidin."[1] "When acted upon by ammonium sulfid (a derivative of putrefactive decomposition of albumin), hemosiderin becomes black, iron sulfid being formed."[2] Grohe[3] believes that as a result of putrefaction iron is liberated from its compound with hemoglobin, so that when thus freed it readily combines with the hydrogen sulfid.

Iron is the most important element to be considered in the list of factors causing the discoloration of this group of cases. It is the iron constituent of the red corpuscles which is the essential chromogenic factor from first to last in their cycle of color changes.

The process of putrefactive decomposition consists of a series of chemical changes wrought out through the agency of microörganisms, involving the breaking down by successive stages of highly complex organic compounds and their resolution into compounds of much simpler constitution. It is not known to what extent this splitting up of the components of the pulp and its vascular elements is ultimately carried in the series of changes resulting in the permanent discoloration of the tooth. From what is known of the ultimate composition of the compounds involved it may, however, be safely inferred that, reduced to its lowest terms, the result, so far as pigmentation is concerned, would be the formation of iron sulfid, the elements of which, with the exception of some unimportant alkaline and earthy salts, are the only ones entering into the original compounds which are fixed and therefore capable of forming a stable residuum in the tubular structure of the dentin. While iron sulfid as such cannot be held wholly accountable for the final bluish-black color of a tooth which has reached the stage

[1] Ziegler, General Pathology, 1895. [2] Ibid. [3] Virchow's Archiv, Band xx.

of permanent discoloration, the pigmentation is almost certainly due either to it or to some allied compound in which iron and sulfur, with some organic constituents, largely enter, and which by a further slight decomposition would yield true iron sulfid.

The significance and importance of a recognition of the possible presence of the iron compound as a factor in tooth discoloration is further brought out in the study of bleaching methods.

Discoloration of Teeth following Death of the Pulp Consequent upon its Exposure.—When death and decomposition of the pulp are consequent upon exposure of that organ, through caries or otherwise, to the irritative influences of infective agents present in the oral secretions and food, or to thermal shock, etc., the putrefactive process involving the pulp tissues is modified in character and rapidity to a degree which may affect the character of the resulting discoloration. Thus, the yellowish or brownish discoloration so often seen in teeth whose pulps have been devitalized through systemic or traumatic causes, and which in many cases appears to be more or less permanent in character, is rarely observed in those teeth whose pulps have been devitalized through exposure by caries.

In these latter cases the original suffusion of the dentin by hemoglobin has ordinarily not taken place and, moreover, the progress of the putrefactive process is comparatively rapid, the conditions being more favorable, so that the coloring matter of the blood is sooner reduced to its lowest terms in the scale of decomposition products, *i. e.*, to the slaty blue or black pigmentation before noted. The pigmentation of the dentin in cases of pulp exposure with subsequent decomposition of that organ is due to the diffusion of some of the decomposition products of hemoglobin that have been formed in the pulp chamber and not in the tubuli as in the class of cases first considered. In addition to the increased rapidity of putrefactive decomposition incident to cases of discoloration following pulp exposure, another and important modifying factor in the process of discoloration is the ingress afforded to the oral fluids, food materials, and other adventitious substances which find their way into the mouth, and ultimately, through the open cavity of the tooth, to its pulp canal, and thence to the tubular structure of the dentin. These extraneous substances, in the course of time, may infiltrate the tooth structure, and while no especially noticeable or characteristic effect may be observed so far as color is concerned, yet they frequently exert an influence upon the coloration of the tooth which so alters its character as to render successful bleaching treatment extremely difficult and a resort to special methods or a variety of methods necessary.

The introduction of fatty or oily substances or of astringent and coagulant matters, for example, may act upon the coloring matter in such a way as to "set" it permanently in the same manner that

mordants form insoluble compounds or lakes with the dyestuffs used in the dyeing of textile fabrics.

Another and important class of substances which frequently are the cause of staining of the tooth structure are metallic salts which are used in dental therapeutic treatment or are accidentally formed during the application of corrosive medicaments to the teeth, through the action of such remedies upon fillings *in situ* or upon the instruments by which the applications are made. For example, the use of iodin or sulfuric acid or other metallic solvents in connection with steel instruments and the subsequent use of medicaments containing tannin as an ingredient.

The treatment of these conditions will be separately considered.

Teeth Suitable for the Bleaching Operation.—In deciding upon the advisability of attempting the bleaching operation in any given case, the general conditions which determine the judgment of the operator with respect to all dental operations should govern his course.

As all therapeutic and restorative measures in dentistry are a series of compromises with disease conditions or their sequelæ, it is the duty of the operator under all circumstances to capitulate upon the basis of greatest advantage to the patient. Therefore, if discoloration of a tooth is practically the only factor in the problem presented by a given case, the effort should be made to restore the organ to its normal condition of color. The same rule should be applied to all cases of discolored teeth in which structural loss by caries or fracture has not been so great as to preclude a satisfactory restoration by proper filling or replacement of the lost structure by a porcelain inlay. The cases in which it is not advisable to attempt a bleaching operation are only those in which loss of structure is so extensive as to require a crowning operation.

In the judgment of many operators it is considered useless to attempt the bleaching of any teeth excepting the incisors, because of the difficulty and length of time frequently required for the successful bleaching of canines, bicuspids, and molars, owing to the thickness of their walls and the consequent depth of the structure requiring treatment. It is also held to be useless to attempt the bleaching of teeth which have been discolored by metallic stains throughout their structure. The fallacy of such a view is self-evident when it is considered that if any portion of the dentinal structure of a discolored tooth is amenable to the bleaching treatment, its complete restoration is simply a question of continuance or repetition of the operation until the desired end is attained.

With regard to discoloration by metallic stains, while teeth so affected present problems of great complexity, and require not only special study but the application of special methods of treatment based upon proper recognition of the chemical relationships involved between the nature of the stain and that of the agent used for its removal, the

attempt should be made in justice to the patient, even though ultimate failure result, in order that the necessity for destruction of the natural crown for the purpose of its replacement by an artificial substitute may, if possible, be postponed for as long a period as may be attainable.

Nature of the Problem Involved in Tooth Bleaching.—The bleaching process is dependent upon a chemical reaction between a compound having color and some substance capable of so affecting its composition that the color is discharged, or, in other words, of so affecting the integrity of the color molecule as to destroy its identity, which results in a loss of its distinguishing characteristic, viz., its color.

The substances concerned in discoloration of tooth structure, as has been previously shown, are derived from the pulp and its vascular elements and the organic contents of the tubular structure of the dentin, through the gradual putrefactive processes which become operative subsequent to the death of the pulp. These pigmentary products of pulp decomposition we know to be organic in character; and further, that they exhibit the property of color by virtue of definite conditions of molecular composition—that is to say, a certain arrangement of a definite kind and number of atoms has resulted in the formation of a molecule having its individual group of chemical and physical properties, among which latter is a characteristic *color.*

Whatever brings about an alteration in the composition of the molecule at once destroys the identity of the matter so treated. Hence, if we can act upon the coloring matter which gives rise to the staining of a tooth by means of an agent capable of effecting an alteration in the atomic arrangement of composition of the color molecule, we may expect incidentally to remove or discharge its color feature.

Two general classes of substances have been successfully used as bleaching agents: First, those which act by virtue of their power to evolve oxygen in the active or nascent condition, and known as oxidizing agents; second, those which act in an opposite manner by virtue of their strong affinity for oxygen, and which are called reducing agents. The oxidizing bleachers destroy the identity of the color molecule by seizing upon its hydrogen element to form water. The reducing agents act by removing the oxygen atom from the color molecule to form by-products depending upon the character of the reducing agent used.

Chlorin and its cogeners iodin and bromin act as indirect *oxidizing bleachers;* the dioxids of hydrogen and of sodium are direct oxidizers. Potassium permanganate may also be classed with this group, although its successful use as a bleaching agent depends upon a subsequent treatment of the substance to be bleached with some solvent capable of removing the manganese dioxid formed as a by-product of the action of the permanganate. It has somewhat extensive and satisfactory use as an agent for bleaching sponges, and has been used for bleaching teeth, but is of greatly inferior value to other agents for the latter use.

The only agent belonging to the group of *reducing bleachers* which has thus far been found available for bleaching teeth is sulfur dioxid, either in the gaseous condition or in aqueous solution.

Chlorin as a Bleacher.—The general use of chlorin as a bleaching agent in the arts no doubt suggested its use in the treatment of tooth discoloration. Its introduction as a tooth-bleaching agent, as well as the assembling of the general principles of its use for tooth bleaching into a coördinated system, are due to Dr. James Truman, whose method depends upon the liberation of chlorin from calcium hypochlorite, commonly called bleaching powder or "chlorinated lime," in the pulp chamber and cavity of decay in the tooth. Chlorin is liberated from the bleaching powder by the action of dilute acetic acid; this taking place in contact with the discolored structure it is rapidly bleached as a result of the action of the chlorin upon the coloring matter contained in the dentinal tubules. Numerous modifications of this original method of bleaching tooth structure have been suggested, but, as the ultimate result in each is accomplished through the activity of chlorin, a rational understanding of the mode of action of chlorin in this relation is of importance as an aid to the intelligent use of those methods for tooth-bleaching which are dependent upon or owe their efficacy to that agent.

Chlorin is an elementary gaseous body, greenish in color, soluble in water, having a disagreeable odor, intensely irritating to the air passages when inhaled, and poisonous when breathed in sufficient quantity. It has a strong affinity for all metallic bodies, entering into direct combination with a number of them, under favorable circumstances, with great energy—forming, as a rule, compounds that are soluble in water.

One of its distinguishing features, and one which is directly concerned in its use as a bleaching agent, is its strong affinity for hydrogen. So strong is this affinity, that when a molecule of chlorin is brought into contact with a molecule of water under favorable conditions, the hydrogen of the water molecule is seized upon by the chlorin to form chlorhydric acid, and the oxygen is set free in the nascent state, a condition under which its oxidizing powers are exhibited in their greatest intensity. This powerful affinity of chlorin for hydrogen enables it to decompose many other hydrogen-containing molecules in a similar manner, forming chlorhydric acid and destroying the identity of the matter acted upon.

It has been shown that all organic compounds which are the products of the vital processes of the animal body contain hydrogen as an important constituent. This applies also to the decomposition products whose presence in the tubular structure of the dentin is the cause of tooth discoloration.

These organic stains exhibit the property of color by virtue of certain definite conditions of molecular composition; hence, if chlorin is caused to act upon the coloring matter which causes the staining of a tooth,

by seizing upon and combining with the hydrogen of the organic pigment, the identity of the compound as such is destroyed, and its characteristic feature, that of color, is lost.

The principle here outlined is involved in what is termed the direct action of chlorin in bleaching. There is, however, another method by which chlorin is believed to act as a bleacher in which its function is indirect.

In some cases it has been observed that chlorin fails to act except in the presence of moisture, and the *rationale* of this is that the bleaching under such conditions is effected by nascent oxygen liberated from the water molecule when the chlorin combines with its hydrogen to form chlorhydric acid; thus: $Cl_2 + H_2O = 2HCl + O$. That such is the nature of the process in many cases is a reasonable deduction from the behavior of chlorin under analogous conditions when it acts indirectly as an oxidizing agent.

Whatever may be the exact nature of its ultimate action, it is to be borne in mind that its bleaching effect is due solely to the alteration which it makes in the composition of the color molecule, and that it has no solvent power whatever on the organic matter upon which it acts. It changes its characteristics, but does not remove it by solution. It should be also noted in this connection that the chlorin compounds of most of the metallic elements, especially when in dilute solution, are almost colorless as compared with many of the other metallic compounds—the oxids and sulfids, for example. Hence it is that when stains owe their color to the presence of certain organic compounds with some of the metals, or even when the coloration is due to decomposition products of hemoglobin, the color may readily be discharged by chlorin; but if the iron chlorid thus produced by the action of chlorin on the iron constituent of the hemoglobin remains in the tooth structure it is gradually decomposed and new combinations of it are liable to occur, which result in a return of the discoloration.

All tooth-bleaching methods should aim not only to discharge the color by suitable chemical means, but should go farther than this, and, as far as it may be possible to do so, remove all organic debris and by-products of the bleaching process from the tubules, for as long as any remain the tendency to a return of the discoloration is always a possible and indeed probable menace to the complete and permanent success of the operation.

When the tubular contents cannot be successfully removed, the tendency to a return of discoloration may be combated by hermetically sealing the tubular orifices with an impermeable resinous varnish or by permanently coagulating them. This feature is described more fully in relation to the details of the bleaching procedure.

Preparation of the Tooth for the Operation of Bleaching.—Certain general details are necessary to be observed in the preparation of teeth for the

bleaching operation, whatever may be the method of treatment employed.

Appropriate treatment for the removal of all septic matter from the pulp chamber and canal, and for the relief of any existing condition of irritation of the pericemental membrane and tissues of the apical region, should have been carried out and the tooth brought to the condition in which permanent closure of the apical foramen of the root may be safely performed.

The rubber dam should be adjusted with special care and only include the tooth to be bleached. If two adjoining teeth are to be bleached, they may both be isolated by the dam; but in no case should one or more adjacent normal teeth be included with the tooth to be bleached. While the inclusion of teeth adjacent to the one which is the subject of any ordinary dental operation is in all cases desirable, there are good reasons why such a plan should not be pursued in the bleaching procedure. The chemicals used for the purposes may possibly have some disintegrating or solvent action upon the enamel structure, and such action, should it occur, should be confined strictly to the tooth undergoing treatment and held within the limits of safety by close observation and appropriate treatment, which conditions cannot be as thoroughly controlled and the process as satisfactorily managed when several teeth are included within the territory of operation.

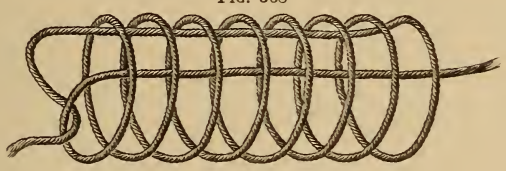
Furthermore, as nearly all of the bleaching agents used or those which are employed as adjuvants to the process have a more or less irritative or escharotic effect upon the soft tissues of the mouth, extra precautions must be taken, in adjusting the dam, against leakage at its attachment to the cervix of the tooth. As the chances of leakage are greatly multiplied when several holes are punched in the dam for adjustment to as many teeth, it is for this reason also that no other than the tooth to be treated should have the dam adjusted to it.

Supposing the tooth to be an upper incisor, the dam should be slipped over it and the margin of rubber encircling the cervix should be gently carried under the free margin of the gum either by means of a small flat burnisher of suitable angle and curvature, or by means of a waxed floss-silk thread. One or two turns of a ligature should then be thrown around the cervix below the dam to hold it securely in place. The dam may be fixed with greater security, especially as against any accidental traction made upon it during the operation, by fastening it with a ligature made as follows and thrown around its cervix:

A piece of waxed ligature silk about eighteen inches in length has a large knot tied at about its middle portion by making six or eight turns of the thread loosely around the end of the index finger of the left hand. Upon withdrawing the finger a series of loops are had through which one of the free ends of the thread is now passed, as in making the first half of a flat knot, as illustrated in Fig. 568. By drawing upon

the free ends of the thread until all of the loops are closed upon themselves, a hard knot of more or less spheroidal shape is formed about midway between the ends of the ligature. The ligature so prepared is placed around the tooth in such a manner that the knot as described shall be located upon and at the middle portion of the palatal cervical margin. A half-knot is then made by tying the ligature in front so that it shall rest directly opposite the palatal knot, viz., at the middle portion of the labial cervical margin. The ligature is drawn into fairly close contact with the tooth, and, with both ends held firmly in the left hand and drawn somewhat tense, the portion encircling the tooth is firmly but gently forced up against the rubber dam and gingival margin, the ligature at the same time being drawn tightly until the anatomical constriction of the tooth at its cervix will serve to hold it from slipping downward, especially upon the palatal aspect of the tooth.

FIG. 568



When the ligature is found to be securely placed as described, the knot upon the labial aspect is completed and further enlarged in bulk by re-tying the thread four or five times. The free ends of the ligature should then be cut off close to the knot. As an additional safeguard against leakage of irritating bleaching agents through the cervical attachment of the dam, and out upon the soft tissues, it is well after making the tooth perfectly dry to paint the ligature and a narrow band of its adjacent territory with chloropercha, which after evaporation of the solvent will effectually prevent any accident from leakage.

The placing of a large knot upon the palatal aspect at the cervical margin has another decided advantage in that it not only holds the dam more securely against slipping downward, but holds it away from the palatal surface, which is ordinarily the point of entrance to the pulp chamber and canals in these cases. The point of canal entrance may, however, be through a proximal cavity, if such a one afford sufficient access.

The canal filling in all cases of bleaching without exception should be gutta-percha. No other material used for canal filling possesses the generally desirable qualities needed for that purpose in this class of cases. The extent of the canal filling should include one-third, or at least not over one-half, of the distance from the apex. A considerable portion of the canal beyond the level of the gingival margin is thus left unfilled in order that the coronal end of the root may be bleached

as well as the tooth crown. This is especially necessary when more or less recession of the gum from its normal attachment has occurred, leaving the cervical cementum exposed to the action of the oral fluids, food, etc., which have a tendency to cause discoloration of the exposed root tissue.

The root being filled as directed, all fillings wherever existent in the tooth should be removed. This is a preliminary procedure which should not be omitted in any case, but where any bleaching method is used which involves the employment of chlorin as the active agent it becomes imperatively necessary for reasons which are explained in connection with the description of the chlorin methods. Aside from other considerations, the removal of all fillings preparatory to the bleaching operation has a decided value in facilitating the process by exposing an increased area of the dentinal structure and thereby permitting the action of the bleaching agent over a larger territory of ingress.

When all fillings or softened tooth structure have been removed, as well as all septic and extraneous matter of whatever character, by mechanical process, the tooth should be washed thoroughly with dilute ammonia water, or better with a hot solution of borax in distilled water in the proportion of ℥j to f℥j. The object of this treatment is to remove by saponification and solution all fatty matters which may obstruct the ingress of the bleaching agent into the dentinal structure.

In nearly all cases where discoloration has occurred from a decomposed pulp, and where the canals and pulp chamber have been left untreated, there will be observed, on opening into such a pulp chamber for the first time, a dark layer of oily or greasy material lining its walls. The thorough removal of this dark layer should be effected prior to any attempt at bleaching, as it appears to prevent the ingress of the bleaching agent into the dentinal structure. The most satisfactory method for removing the dark greasy layer is by the use of suitable instruments—either properly shaped spoon or hoe excavators or round burs in the engine. The thorough removal of this layer necessitates free access to the pulp chamber, which should be, as a general rule, obtained by means of an ample opening upon the lingual aspect of the tooth in the case of incisors, and through the morsal surface in bicuspids, etc.

Having by mechanical means and through the agency of borax or ammonia and hot distilled water effected a thorough cleansing of the interior portion of the tooth, it should next be dried to the extent of having all superfluous moisture removed, and it will then be in condition for the application of whatever method of bleaching may be chosen for the particular case in hand. When sodium dioxid or Schreier's kalium-natrium with hydrogen dioxid are to be used as the bleaching agents the preliminary saponification of the canal contents with ammonia or hot borax solution becomes unnecessary.

Truman's Method.—This, as before stated, was the first method successfully employed for bleaching teeth. It consists in liberating chlorin from ordinary chlorinated lime by means of a weak acid in the pulp chamber of the tooth. Any acid will effect the liberation of chlorine from the bleaching powder, but acetic, tartaric, or oxalic are generally used. Care must be observed in selecting a good quality of bleaching powder, as that substance rapidly undergoes decomposition spontaneously, especially in a moist atmosphere. Good chlorinated lime is a dry powder having a strong odor of chlorin. If it is moist or pasty, and has but a feeble odor, it should be rejected as worthless. Brands of bleaching powder dispensed in metallic packages should not be used, as they are invariably contaminated with metallic chlorids due to the slow action of the contents upon the containing package. This is particularly the case when sheetiron boxes are used. The return of discoloration in many cases after bleaching by the Truman method is undoubtedly due to the use of bleaching powder so contaminated. The powder dispensed in glass bottles or in paraffined paper cartons is more reliable.

Its application to the tooth may be effected in several ways:

(*a*) By packing the dry powder in the pulp chamber and then moistening the latter with the acid.

(*b*) By mixing the powder with sufficient distilled water to make a coherent mass which is more easily manipulated, then packing it in the pulp chamber and applying the acid.

(*c*) By first moistening the interior of the tooth with the acid, next dipping the instrument into the powder and then into the acid, each time carrying the mixed materials into the tooth until the desired change of color is produced.

Probably the most satisfactory method is to pack the dry powder into the tooth and apply the acid to it, after which immediately seal the cavity with a single pellet of gutta-percha. By using a 50 per cent. solution of acetic acid the evolution of chlorin will take place with a satisfactory degree of uniformity, and not so rapidly as to interfere with its penetration throughout the discolored tubular structure of the dentin. The bleaching mass may be sealed in place by means of zinc oxyphosphate if desired, but it is usually unnecessary to use anything other than gutta-percha or one of the soft temporary stopping materials for this purpose.

The case may be dismissed for one or two days and the treatment as outlined repeated at similar intervals until the tooth is restored to normal color.

The instruments used in connection with this process should be of vulcanite, bone, ivory, or wood. Upon no consideration should steel, gold, or platinum instruments be used, as chlorin acts directly upon each of these metals, forming soluble chlorids, which if carried into the

tooth structure will give rise to a permanent staining of most intractable character. The only metals which may be safely used in connection with any chlorin process of bleaching are zinc and aluminum, the chlorids of which are colorless, but, nevertheless, they are objectionable for the reason that both are coagulant and color mordants. Aluminum instruments for the purpose may be quickly improvised out of wire or heavy plate. Gold instruments have been recommended, but they are open to the very grave objection of forming a chlorid by direct combination with chlorin, which salt is one of the most important staining media known to the histologist; as a matter of fact, the writer has seen several cases where a permanent purple staining of the tooth has resulted from neglect to remove gold fillings before applying the chlorin method of bleaching, and there is certainly no reason why the same result should not follow the using of gold instruments in the same connection.

When the tooth has been restored to its proper color it should be thoroughly washed with liberal quantities of very hot distilled water, dried out with bibulous paper, and thoroughly desiccated with a current of dry hot air, after which the canals, pulp chamber, and cavities should be filled with zinc oxychlorid.

The final filling of the cavities of entrance and of decay should be postponed until, by a lapse of considerable time, the permanence of the operation has been established. This probationary period may with advantage be prolonged to four or six months.

The final washing of the tooth with hot distilled water previous to the insertion of the zinc oxychlorid filling is a feature of the operation which requires special care and attention. As left after the application of the bleaching agent, the pulp chamber and canals and dentinal structure are filled with free chlorin in solution, iron chlorid from the combination of the chlorin with the iron element of the color molecule, calcium acetate, or other salt of calcium, depending upon the nature of the acid used in the process, and probably some undecomposed bleaching powder. These substances should be thoroughly removed by the hot-water douche. At least a pint of water should be strongly injected into the interior of the tooth, by means of a large bulb syringe or other convenient means, before the dam is removed. A thick towel held in close proximity to the tooth will catch the water as it returns from the tooth and protect the clothing of the patient. Distilled water should in all cases be used for this irrigating douche, as river water and many other specimens of water from natural sources contain iron in solution, which could readily become a contaminating factor, leading to subsequent return of discoloration.

Zinc oxychlorid is selected as the permanent filling for the pulp chamber, for the reason that it is necessary so to act upon the bleached organic residuum in the tubular structure as to prevent any alteration

of its character which may result in the production of a subsequent coloration. Zinc chlorid possesses the property of converting many organic substances into unalterable compounds by its coagulant action, thus tanning or mummifying animal tissue and preserving it indefinitely. A mass of zinc oxychlorid, before it sets—*i. e.*, before chemical combination takes place between the zinc oxid powder and the zinc chlorid liquid, is functionally free zinc chlorid—and, as a matter of fact, the properties of zinc chlorid are manifested by such a mass for a considerable period of time after the mass has apparently set. When introduced into the pulp chamber and canal, its action upon the organic debris in the tubuli is as stated, and the material, if the operation has been successfully performed, is effectually prevented from further alteration, upon which condition the permanence of the operation depends.

Another method for preventing subsequent alteration of the bleached organic debris in the tubular structure is to desiccate the tooth thoroughly by means of the hot-air blast and saturate the dentin with some insoluble resinous varnish, such as copal ether varnish, or, what is still better, the solution of trinitrocellulose in methyl alcohol and amyl acetate, known in commerce as "kristaline," or at the dental depots as "cavitine." The pulp chamber and canals may then be filled with any suitable filling.

As between the zinc oxychlorid filling and the varnish lining, the choice in general should be of the former. The varnish lining is adaptable more especially to cases of long standing, where complete liquefaction of the tubular contents has left them practically empty, and where, as a consequence, there is nothing upon which zinc chlorid can exert its coagulating effect.

Other Chlorin Methods.—The solution of chlorinated soda known as Labarraque's solution, or Liquor sodæ chloratæ U. S. P., may be applied to the previously desiccated tooth structure until the dentin is saturated with the solution, after which an application of a dilute acid is made which liberates chlorin. The chemical principles involved are exactly analogous to those upon which the method with bleaching powder depends, the only difference being that the source of the active agent, chlorin, is in one case its calcium compound, which is a dry powder, and in the second case the analogous soluble sodium compound of chlorin is the material from which the active agent is evolved.

The precautions necessary to be observed are exactly the same as those required in Truman's method, already described. The results obtained by this process are not as thorough or as satisfactory as by the Truman method.

Chlorin *per se* has been used for tooth bleaching, and was the basis of a method devised by Dr. E. P. Wright, of Richmond, Va.

Wright's Method.—This involved the use of a complicated apparatus by which a glass vessel of about a half-liter capacity, and filled with

chlorin previously prepared in the laboratory, was connected by means of a doubly perforated rubber stopper and two pieces of rubber tubing with a glass adapter, around the open end of which was tied the rubber dam encircling the tooth to be operated upon. About midway of the length of one of the rubber tubes connecting the chlorin reservoir with the rubber dam was interposed an ordinary syringe bulb, so arranged with hard-rubber valves that by repeatedly compressing and relaxing it the chlorin would be drawn from the reservoir and injected through a glass delivery jet into the pulp chamber. Return of the gas to the reservoir was provided for by the second piece of rubber tubing first alluded to. In this way a continuous jet of chlorin was thrown into and about the tooth, which, by means of the rubber dam, was placed in a close chamber forming a part of the apparatus; none of the gas could escape into the surrounding atmosphere. The complexity of the apparatus was a formidable obstacle to the general use of the method, and it was abandoned, though the results were in many cases very satisfactory.

Iodin.—Reference has previously been made to iodin as a bleaching agent. Its chemical action is quite analogous to that of chlorin, though less energetic. In slight discolorations, however, iodin may often be used to considerable advantage by simply saturating the dentin with an alcoholic solution of iodin—*e. g.*, the official 7 per cent. tincture—until the tooth structure is stained a characteristic yellow. The cavity is then sealed temporarily with a gutta-percha filling and the case dismissed for twenty-four hours, at the expiration of which period a marked improvement in color will be observed. The same precautions as with the use of chlorin in regard to the removal of metallic fillings and the avoidance of contact with metallic instruments is necessary in the use of iodin for bleaching purposes.

THE DIOXID BLEACHING METHODS

Bleaching by Means of the Dioxid of Hydrogen and of Sodium.—The commercial introduction of solutions of hydrogen dioxid marked a new era in the operation of bleaching discolored teeth. The bleaching property of hydrogen dioxid had been known to chemists for many years, but the application of this property to tooth-bleaching dates from the medicinal use of hydrogen dioxid solutions for the treatment of purulent conditions of the pulp canal and about the roots of teeth. When applied in the canals of discolored and infected teeth it was observed that a noticeable bleaching of the discolored structure resulted. The hint thus given was further studied until it was found that under proper conditions the whole structure of a discolored tooth might be successfully restored to normal color.

The earlier preparations were found to be lacking in strength; aqueous

solutions containing more than 3 or 4 per cent. of absolute hydrogen dioxid were found to be too unstable to keep for any length of time, and hence were unreliable. The problem of securing a stable high-percentage solution of the dioxid was solved by using ether as a menstruum, and the 25 per cent. solution of hydrogen dioxid, sold as "caustic pyrozone," is now generally used when hydrogen dioxid is employed as a bleaching agent in connection with discolored tooth structure.

Subsequent to the introduction of the pyrozone preparations, the firm of Merck has produced a 100-volume solution of hydrogen dioxid under the trade name of Perhydrol, which is the most active and efficient of the hydrogen dioxid preparations as tooth-bleaching agents.

Hydrogen dioxid, H_2O_2, belongs to the class of "oxidizing bleachers," and owes its activity in this respect to the weak state of chemical combination in which one of its atoms of oxygen is bound to the water molecule. Many substances serve to disrupt the compound and liberate one of its oxygen atoms. In contact with pus, blood, inspissated mucus, albumin, and in fact almost every kind of dead organic matter, its decomposition takes place, evolving oxygen and decomposing the organic matter either wholly or in part. Hydrogen dioxid does not bleach all of the decomposition products of hemoglobin with equal facility. It quickly removes the pink discoloration following the initial extravasation of hemoglobin into the dentin, but when the brown stage has been reached, indicative of the formation of hematin, its action is but slight. Later, however, it bleaches more readily. The refractory nature of hematin with respect to hydrogen dioxid has been experimentally tested upon the substance out of the mouth.

It is important to note that all acids promptly convert hemoglobin into hematin, which is highly resistant to the action of hydrogen dioxid; therefore, whenever hydrogen dioxid is used to bleach a tooth in the primary or pivot stage of discoloration the hydrogen dioxid should be made alkaline with sodium carbonate or hydroxid to neutralize at least its usual slight acidity, otherwise its acid content will act upon the hemoglobin, converting it into hematin, and thus set the color in such a way as to be invulnerable to the action of the hydrogen dioxid.

In bleaching discolored teeth with hydrogen dioxid, perhydrol or the ethereal 25 per cent. solution known as pyrozone is directly applied to the internal portions of the tooth upon small pledgets of cotton or cotton wisps rolled upon a fine flexible canal instrument. After each application the menstruum is evaporated by blasts of warmed air from a hot-air syringe, and the applications similarly made are repeated until the desired effect is produced. It has been found in practice that more rapid and permanent effects are produced when the solution is rendered alkaline. This may be readily done by the addition of a few drops of liquor ammoniæ fortior or by a solution of one of the

caustic alkalies, *e. g.*, sodium or potassium hydroxid or sodium dioxid. A very satisfactory method of securing the alkaline effect in this process is that suggested by Dr. D. N. McQuillen. His method is to first treat the pulp chamber and canals with applications of Schreier's Kalium-natrium preparation, and after the debris from its action has been mechanically removed with instruments and cotton twists, without washing the canal, an application of pyrozone is made. The bleaching action follows with great rapidity, and has apparently greater permanence than when the pyrozone is used alone. In cases in which the action proceeds very slowly—for example, when at the end of a thirty minutes' continuous treatment the bleaching is not complete—it is well to seal an application of pyrozone upon cotton in the canal and allow it to remain for twenty-four hours, when a second treatment will usually complete the operation.

In this, as in all bleaching operations, it is advisable to fill the tooth temporarily with some easily removable filling in order to test the permanence of the operation, and after the lapse of a reasonable time, if there is no tendency to a return of the discoloration, the canals and cavity may be permanently filled.

Harlan's Method.—This consists in acting upon hydrogen dioxid by aluminum chlorid. The aluminum salt is packed in the cavity and moistened with the dioxid. The technique of the procedure is the same as for the methods already described. This process was originally classified with the chlorin methods, as the decomposition was supposed to take place according to the following equation:

$$Al_2Cl_6 + 3H_2O_2 = Al_2O_3 + 3H_2O + 6Cl.$$

Experimental study of the reaction between aluminum chlorid and hydrogen dioxid by the writer developed the fact that oxygen and no chlorin was given off, and that the aluminum chlorid was unaltered during the process. Hence it was discovered that the reaction was simply due to a catalytic action of the aluminum salt (a property which in this relation it shares in common with many other metallic salts), whereby nascent oxygen is liberated from the hydrogen dioxid. The process, therefore, has no greater value than those in which hydrogen dioxid is directly applied. The aluminum chlorid, being an active coagulant, is contraindicated as a factor in the bleaching process until a point had been reached where a coagulant is needed as a fixative after the bleaching has been effected.

The Sodium Dioxid Method.—Sodium dioxid, Na_2O_2, is the chemical analogue of hydrogen dioxid, and like the latter is characterized by the readiness with which it parts with its atom of loosely combined oxygen under similar circumstances. The essential difference in its properties is the character of its by-product after its decomposition

has taken place. Itself a strong caustic alkali, it still retains its alkaline and caustic properties after the loss of one of its atoms of oxygen, becoming Na_2O, which in combination with water is ordinary sodium hydroxid or caustic soda. This substance, as well as the sodium dioxid, has not only a saponifying property for all of the vegetable and animal oils and fats, but also a solvent action upon animal tissue. This property is of great value in removing from the dentin structure all of the contained organic matter, whether normal or in a state of decomposition. Having the oxidizing and consequently the bleaching quality in addition to its solvent and saponifying properties, it is, therefore, one of the most valuable bleaching and detergent agents at our command. The substance is dispensed as a yellowish-white powder in tin cans or glass bottles hermetically sealed, as it is very hygroscopic, and after twenty-four hours' exposure to moist air absorbs nearly its own weight of water; it also loses much of its activity.

For use as a bleaching agent, it is applied to the dentin in saturated solution. In making the solution, special care is necessary in order to avoid elevation of temperature, by reason of the energy with which it enters into combination with the water. If the solution is allowed to become heated in the making, decomposition of the compound with loss of oxygen occurs, and its bleaching power is destroyed. The solution is best made by pouring into a small beaker, of about one ounce capacity, about two drams of distilled water, and immersing the beaker in a larger vessel or dish containing iced water or pounded ice. The can containing the dioxid powder should then have its lid perforated with a number of small holes similar to the lid of a pepper shaker, and the powder be slowly dusted into the distilled water in the small beaker; or the powder may be gradually dropped into the water by tapping it from the point of a knife or spatula. The powder is added to the water until the solution assumes a semi-opaque appearance, indicating the point of saturation.

On removing the beaker from the cooling mixture, the dioxid solution will in a few minutes assume a transparent, straw-colored appearance and is ready for use.

The applications are to be made similarly to the hydrogen dioxid applications, but upon asbestos fiber instead of cotton, as the latter is acted upon by the sodium dioxid and converted into a glue-like material, amyloid, which is difficult to remove and interferes with the success of the operation.

After the dentin, which should have been previously desiccated, is thoroughly saturated with the dioxid solution, an application of 10 per cent. sulfuric acid should be made, which neutralizes the strong alkali, forming sodium sulfate and hydrogen dioxid, thus:

$$Na_2O_2 + H_2SO_4 = Na_2SO_4 + H_2O_2.$$

The reaction is usually attended with some effervescence, which, taking place in the tubular structure of the dentin, mechanically forces out its contents and thus exerts a detergent action upon it. The tooth should now be washed with hot distilled water in copious quantity and the dioxid application repeated, omitting the subsequent treatment with acid, but washing again thoroughly with the hot water.

Sodium dioxid solution, as prepared for bleaching, may be applied to the pulp chamber and root canal without the preliminary treatment required where other bleaching agents are employed. It is without harmful irritative action upon the apical tissues unless used in excess or forced through the foramen by careless manipulation. It is a powerful germicide and disinfectant, and therefore peculiarly suited to the treatment of putrescent cases, which by its action are rendered sterile and aseptic as well as bleached at one operation. Its saponifying and solvent properties completely remove the greasy dark layer of decomposed material which is found lining the pulp chamber and canals alluded to on page 530, so that the use of the sodium dioxid method makes unnecessary the application of borax or ammonia for its removal as a preliminary. When used for its sterilizing property the foramen should be allowed to remain unsealed until after the bleaching operation has been completed. It sometimes happens that the improvement in color following the application of the dioxid methods is only partial, and the result falls short of restoration to normal; or, in other words, the bleaching reaches a certain point beyond which the color resists the further action of the bleaching agent. In such cases the decomposition of the color molecule has probably resulted in the formation of iron oxid as an end product. In practice this residual discoloration can generally be removed by treatment with oxalic acid. A small crystal is to be sealed in the moist pulp chamber for twenty-four hours, and afterward washed out with a copious irrigation of hot distilled water.

The sodium dioxid method removes more completely than any other the tubular contents, and the result is unique from the fact that not only is the tooth restored to normal color, but to normal translucency; the opaque white effect resulting from other methods of bleaching is due to the bleached organic debris remaining in the tubuli, but by the solvent action of the strong caustic alkali this is removed. The final treatment of the tooth is the same in this as in other methods, though the dentin should be desiccated and saturated as thoroughly as possible with an unalterable varnish before the final filling is inserted.

The Sulfur Dioxid Method.—Reference has already been made to sulfur dioxid as the single example of the reducing type of bleaching agent. Its activity is due to its affinity for oxygen, and it bleaches by seizing upon and combining with that element of the color molecule, thus destroying its identity and consequently its color. Attempts have been made to utilize the bleaching property of sulfur dioxid in the

treatment of discolored teeth by direct applications of the solution of the gas in water and by igniting small quantities of sulfur in the root canal by means of the electrocautery wire. These methods have, however, proved inefficient. The gas may be successfully used in bleaching teeth by evolving it from its compounds placed in the cavity and root canal in a manner analogous to that employed in the Truman chlorin process, already described. For this purpose the writer's method may be conveniently employed: 100 grains of sodium sulfite and 70 grains of boric acid are separately desiccated and afterward ground together in a warm dry mortar. The powder is then to be transferred to a tightly stoppered bottle. For bleaching purposes the powder is packed into the root canal and cavity of the tooth, and then moistened with a drop of water and the cavity immediately closed as tightly as possible with a stopping of gutta-percha previously prepared and warmed. A reaction ensues between the boric acid and sodium sulfite whereby sulfur dioxid is liberated, thus:

$$2H_3BO_3 + 3Na_2SO_3 = 2Na_3BO_3 + 3H_2O + 3SO_2.$$

The process is effective in many cases in which the chlorin methods have failed, but is slow in its action, and is largely superseded by the hydrogen dioxid and sodium dioxid methods.

CATAPHORIC BLEACHING OF TEETH

It has been found that aqueous solutions of hydrogen dioxid may be carried into the dentinal structure with great ease by the cataphoric action of the continuous current. The appliances necessary for tooth-bleaching operations by this means are practically the same as those required in the treatment of hypersensitive dentin. The resistance offered by the hard structures of the tooth is much greater after loss of the tooth pulp, requiring a much higher voltage pressure to drive the bleaching agent into the tissue. While in some cases 25 to 30 volts will be all that is necessary, some cases will require as high as 60 volts to carry 1.5 milliampères of current through the dentin. The ethereal solution of hydrogen dioxid has been found to oppose too great resistance to the current, but the aqueous solution, containing a slight addition of some salt to increase its conductivity, is entirely manageable.

A 25 per cent. aqueous solution of hydrogen dioxid may be quickly made by shaking together in a test-tube one volume of water and two volumes of 25 per cent. pyrozone. The H_2O_2 dissolves in the water, and the ether of the pyrozone may be removed by pouring the mixture into a small evaporating dish of porcelain or glass and gently heating it over a water bath until all of the ether has evaporated. The addition

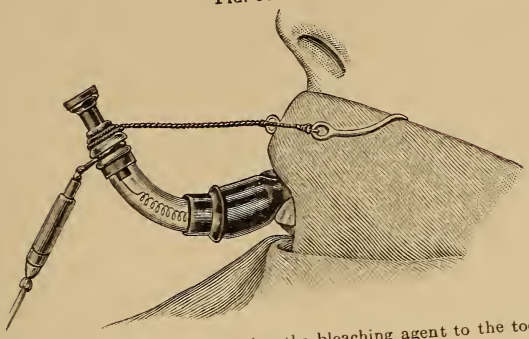
of a small quantity of sodium acetate or sulfate will greatly diminish the resistance of the solution to the passage of the current.

With the tooth isolated by the rubber dam and having received the treatment preliminary to bleaching, as already described in detail, the aqueous solution of H_2O_2 is dropped upon cotton within the tooth cavity and a platinum needle anode is applied in contact with it. The cathode may be a sponge electrode moistened with salt solution and held in the hand or applied to the cheek or neck. The hand, however, is preferable because of the amount of voltage required in the operation. Great care must be exercised that the external surfaces of the tooth are kept dry, so that short-circuiting of the current may not take place. In some cases a more rapid effect is obtained by making contact of the cathode pole through a needle electrode upon the external surface of the tooth, and with the anode applied to the pyrozone solution on cotton within the tooth. The cotton must at all times be kept wet with the solution.

The arrangement of the electrical terminals with respect to the bleaching operation is both theoretically and practically correct as described, viz., the flow of current should be from the anode point through the bleaching solution and tooth and the body of the patient to the cathode. In practice it has been found in some cases which have failed to bleach with the elements arranged in the series as stated, that upon reversing the poles and direction of current flow the bleaching has rapidly followed. The explanation of this apparent paradox is that by the application in normal order H_2O_2 was first carried into the tubular structure, and the reversal of the current has acted upon the tubular contents now saturated with the dioxid, and by its propulsive as well as electrolytic effect removed the pigmentary matter pulpward from the tubuli. Bleaching with reversed poles would be impossible without previous saturation of the dentin by the dioxid solution.

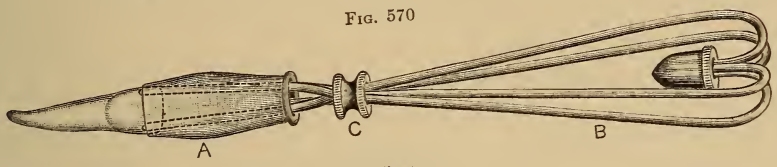
Dr. M. W. Hollingsworth has devised an ingenious apparatus for cataphoric bleaching which is of special value, as it makes possible the enveloping of the entire tooth with the bleaching fluid, in which it is immersed as in a bath. The appliance is shown *in situ* in Fig. 569, and consists of a thin vulcanized caoutchouc bulb shaped like the bulb of a medicine dropper. Through a perforation at its rounded end, made with the ordinary rubber dam punch, the tooth is slipped by mounting the bulb on the applicator (Fig. 570), and forcing it over the tooth as though it were a rubber dam. A glass tube is then attached to the open end of the bulb, and to the glass tube is connected a spiral platinum wire electrode (Fig. 571). Before the electrode is attached the bulb and glass tube are completely filled with the aqueous pyrozone solution by means of a duplex syringe (Fig. 572), the lower and larger bulb of which exhausts the contained air in the apparatus and the smaller thumb bulb injects the bleaching solution into the

Fig. 569



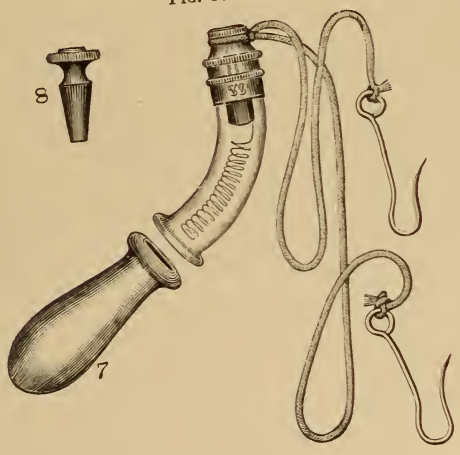
Hollingsworth's device for applying the bleaching agent to the tooth.

Fig. 570



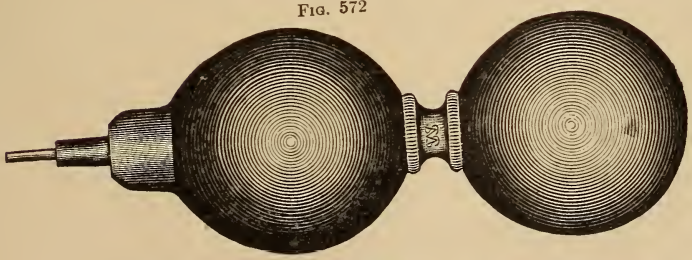
Applicator.

Fig. 571



Tube electrode.

Fig. 572



Duplex syringe.

exhausted apparatus. Connection is now made with the source of current as usual, and the bleaching is very rapidly effected. Dr. Hollingsworth recommends the addition of about 1 per cent. of zinc sulfate to the aqueous pyrozone solution, which not only diminishes the resistance to the passage of the current, but has a coagulating effect upon the bleached organic matter, which gives it translucency and greatly enhances the permanency of the operation. The results obtained by this method are extremely satisfactory.

Actinism as an Adjuvant to the Bleaching Process.—The efficiency of sunlight as a bleacher has long been known and practically utilized in the bleaching of cotton and linen fabrics, both on a commercial scale and in domestic practice. The tendency of vegetable and some mineral coloring matters to fade in the sunlight is a phenomenon of common observation. It is known that the power possessed by light of bringing about chemical changes is a property which is not shared equally by all parts of the solar spectrum, but is most marked in the violet and ultra-violet rays when the undulations are of highest frequency. Advantage has been recently taken of the actinic factor of light as an adjuvant to the tooth-bleaching process in connection with hydrogen dioxid by Dr. Pflüger, of Hamburg. The method consists in making an application of perhydrol on cotton to the pulp chamber of the discolored tooth and also coating the crown with the bleaching agent, then concentrating with a double convex lens a beam of light from an electric arc lamp upon the tooth, which in the course of from fifteen to thirty minutes is restored to its normal color in cases amenable to the bleaching action of the dioxids. Experiments by Dr. Pflüger have shown that when the actinic effect of the light is used the action of the hydrogen dioxid is much more rapid and efficient than when used without the light. Tests of actinic rays with bleaching agents other than hydrogen dioxid have not as yet been made, but the use of the rays in such connection would seem to be promising of usefulness.

BLEACHING METHODS FOR SPECIAL STAINS

Pulpless teeth are specially liable to discoloration from external and accidental causes. If decayed and the cavity has remained unfilled for a length of time, many substances which find their way into the oral cavity either as food or as medicine may produce discoloration when absorbed by the tooth through the open cavity walls.

Metallic salts are particularly apt to cause such staining by reaction with the sulfids with which the dentin structure is usually saturated during decomposition of its organic contents. Many of the medicaments used in pulp-canal treatment, or even for hypersensitive dentin, may stain the tooth structure, and finally the action of sulfids in the

structure of a pulpless tooth may react with amalgam fillings, forming salts of mercury, silver, tin, copper, etc., which are absorbed by the tooth, resulting in its discoloration. The treatment of these stains, which were grouped as Class III at the beginning of this chapter, is extremely difficult and often unsatisfactory. However, there may arise individual cases of discolorations of this class in which it is of the utmost importance to remove them, and much may often be accomplished when the causes of the discoloration are known and the proper bleaching method is applied.

Gold stains may arise, as has been already indicated, from the injudicious use of gold instruments or failure to remove all gold fillings when applying some one of the chlorin methods of bleaching. In the course of time when this has happened the tooth assumes a pinkish hue, which merges into a characteristic violet or purple, finally becoming black.

Iron stains may arise from the use of steel instruments in connection with the chlorin methods of bleaching or in contact with iodin or any of the mineral acids in connection with canal treatment. The iron stain is yellowish at first, gradually becoming brown and finally black.

Copper and nickel stains may arise from contact with these metals or their alloys, as copper amalgam or nickel or German silver dowels for artificial crowns or anchorages for fillings. The stains from these metals are—for copper, bluish to black, and for nickel, a characteristic chlorophyl green, which eventually becomes black.

The best general treatment for all of the foregoing stains is to bleach the tooth by the chlorin method, with special care as to the several precautions already recommended; and when the color of the metallic stain has been discharged by conversion of the dark-colored salt into a soluble chlorid, wash the tooth thoroughly first with dilute chlorin water, 50 per cent., and afterward with hot distilled water, to remove all of the metallic chlorid which has been formed. The process may require repetition to secure permanent results.

Silver stains are comparatively easy to remove, either by an application of the chlorin method or by saturating the tooth with tincture of iodin, thus converting the silver salt into a chlorid or iodid, as the case may be, after which it may be dissolved out with a saturated solution of sodium hyposulfite applied as a bath to the tooth. For this purpose the Hollingsworth bulb dam (see Fig. 569) answers admirably, and although the experiment has not as yet been tried, there is good reason to believe that the cataphoric method with electrodes applied in reverse order would under these circumstances greatly facilitate the solution and removal of the metallic salts.

Mercurial stains are always black from the formation of mercuric sulfid, and are removable by the same method as are silver stains, with the exception that when the stain has been converted into a chlorid

by the chlorin method, the mercuric chlorid is best removed by an aqueous ammoniacal solution of hydrogen dioxid, or when the stain has been converted into mercuric iodid by the use of a saturated solution of potassium iodid. In both cases a final washing with hot distilled water is a *sine qua non.*

Manganese stains frequently occur from the use of potassium permanganate, in solution or in substance, in the treatment of putrescent canal conditions. The manganese stain is a characteristic mahogany brown. It is very readily removed by a 25 per cent. aqueous solution of hydrogen dioxid in which oxalic acid crystals have been dissolved to saturation. A few applications of this mixture will quickly decolorize the stain, after which a liberal treatment of hot distilled water is required as in the foregoing cases.

In all cases a careful diagnosis of the chemical nature of the discoloration should be made when possible. Much information upon this point may be gained by a detailed study of the present condition of the tooth and its environment, but in addition to this the patient should be questioned as to the history of the case, and especially as to its previous treatment. The data thus obtained should be carefully noted, and treatment instituted in accordance with the conditions to be met.

Success in the bleaching of teeth demands a recognition of the fact that each case presents individual peculiarities, that the problem is essentially a chemical one always, and that the bleaching method in any given case must be selected with special reference to the character of the discoloration and applied with due care as to its details in order that the chemical requirements of the operation may be intelligently met; without which care success is impossible.

CHAPTER XVII

EXTRACTION OF TEETH

By M. H. CRYER, M.D., D.D.S.

INDICATIONS FOR THE OPERATION

It is impossible to formulate a set of exact rules by which the practitioner may be governed in deciding upon the extraction of teeth. So many circumstances, both local and general, must be taken into consideration that little more can be done than to suggest the most important causes which demand the operation.

Deciduous Teeth.—The indications for extracting deciduous teeth are—

First: When the teeth are a source of irritation affecting the general health or comfort of the child and do not respond to treatment.

Second: When the deciduous teeth are preventing the eruption of the permanent teeth into their normal positions. Occasionally a deciduous tooth will assist in the proper placing of a permanent one, in which case it should not be removed as long as it is of such use.

Third: When a lower permanent incisor shows signs of erupting on the labial side of the deciduous tooth the latter should be removed at once, but if the erupting tooth appears on the lingual side the removal of the deciduous tooth may in that case be delayed somewhat longer.

Fourth: When upper permanent incisors show a tendency to erupt on the palatal side of the temporary teeth the latter should be extracted, but when they are erupting on the labial side the deciduous teeth may be allowed to remain for a time, as they are often useful in forcing the permanent teeth outwardly. This, however, must be closely watched to prevent the permanent incisors from moving too far.

Permanent Teeth.—The indications for extraction of the permanent teeth are—

First: Diseased roots which cannot be cured and so made useful for crowning, or assisting in retaining a bridge, plate, or other prosthetic device.

Second: Teeth of mastication that have lost their occluding teeth and in consequence thereof are being pushed from their alveoli and are a source of trouble. As a rule, this refers only to the second or third molars, and more particularly to the third molar. When it occurs with other teeth the opposite vacant space should be filled by an artificial tooth to prevent the extrusion of the natural tooth.

Third: When incurable abscesses originating from teeth in the upper jaw tend to open into the nasal chamber, maxillary sinus, or zygomatic fossa the teeth associated with such abscesses should be extracted. When diseased teeth are the exciting cause of an incurable abscess in the lower jaw which opens or threatens to open externally on the chin, jaw, or below the bone into or upon the neck, they should be removed.

Fourth: Teeth which occupy irregular positions in the arch, that cannot be corrected so as to become useful or contribute to the general symmetry of the mouth, should be removed.

Fifth: Erupting teeth that are retarded because of lack of room in the jaw, if giving pain, or are causing reflex disturbances, should be extracted or else the tooth that is preventing the eruption should be removed. A marked example of this is often found in the eruption of the third molar when all the other teeth are of good size and are in place. These molars when retarded often cause the greatest distress, sometimes producing serious results, and must then be extracted; if they cannot be safely removed the second molar may be extracted, in consequence of which the third molar will usually be erupted near its place. When an upper third molar is erupting under the same circumstances there is usually less difficulty, as, having but slight resistance distally, it can erupt outwardly or slightly backward, though should it impinge upon the soft tissues covering the ramus of the lower jaw it should be extracted.

Sixth: Teeth so badly diseased that they will not respond to treatment and are a source of discomfort to the patient should be removed, as they impair the general health.

Seventh: *First molars.* There has been much discussion regarding the early extraction of these teeth, many claiming that if the pulp of one becomes devitalized at an early period of life and it is deemed best to extract it, the other three should also be removed. No fixed general rule, however, can be given; each case must be considered separately. There are cases where the extraction of all is necessary, and others where it would be a most unwise thing to do. When the anterior teeth are fully in position, the bicuspids occluding correctly and the second molars are about to erupt, the case may then be one for extracting the four first molars, provided it be necessary to extract one of them, or if it be likely that one or more of them will be lost in a few years. If, however, the bicuspids are not in good position, it is better not to extract the first molars, as they assist in keeping the jaws the proper distance apart, and in preventing the lower anterior teeth from biting against the upper gum.

Removal of Sound Teeth Preparatory to Inserting Artificial Dentures.— When preparing the mouth for an artificial denture the removal of sound teeth may be indicated as a measure of expediency in relation to mechanical and hygienic considerations. For example:

1. Roots which a plate or bridge would cover, excepting when they assist in holding the device.

2. Teeth from which the gums have receded to such an extent as to become useless or unsightly.

3. Teeth that are being extruded from their alveoli from the absence of occluding teeth. The extraction of these depends, however, on the extent of "elevation" and the possibility of placing occluding artificial teeth in position.

4. Where there is but one tooth remaining, or two teeth standing together, or in certain cases when several isolated teeth remain which cannot be made to contribute to the mechanical adaptation of an artificial denture, extract when in the *upper* jaw. They interfere with the fitting of an upper plate, but in the lower jaw they may be useful in retaining the plate.

5. When there are two teeth, one on each side of the upper jaw, in good position and of desirable shape for clasping, do not extract unless they are the third molars or the oral teeth.

6. In preparing the upper jaw when two canine teeth alone remain, or when there is also a molar or bicuspid, or both, and it is decided to extract the molars and bicuspids, then extract the two canine teeth also. It has been claimed by some of the very best dental practitioners, whose opinions must be respected, that by keeping these teeth the expression of the face is less likely to be marred. For the following combined reasons, however, extraction is advised:

(*a*) It is very difficult to obtain a correct impression of the mouth while these teeth only are in position.

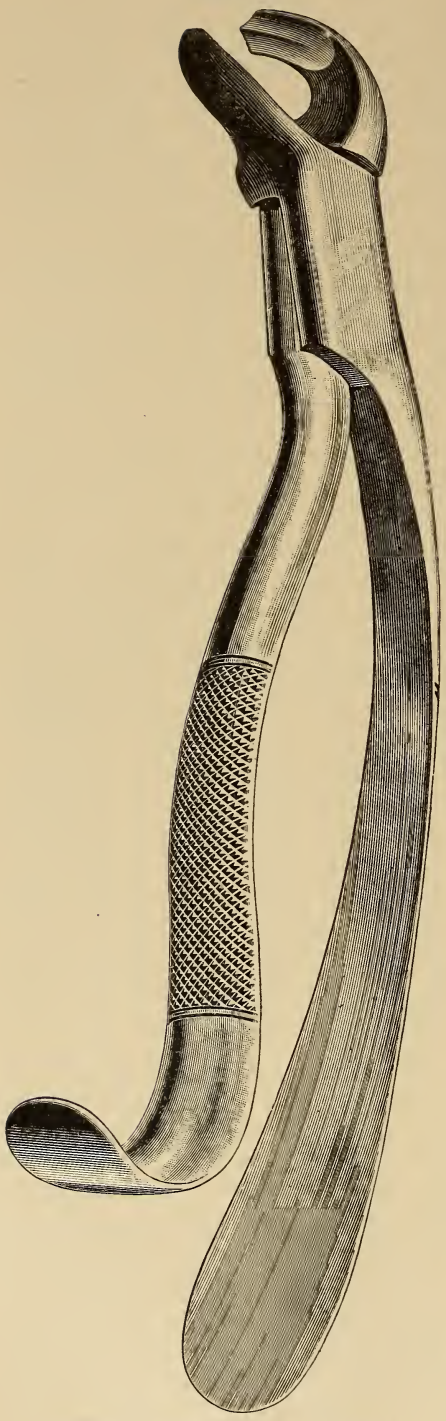
(*b*) It is nearly impossible to perfectly match, grind, and arrange the lateral incisors beside single canines.

(*c*) The adhesion of the plate to the mouth is interfered with, as air and food work in between the plate and these natural teeth.

(*d*) The plate is very much weakened by being cut out for the accommodation of these teeth at what might be termed the abutments of the arch.

In the *lower jaw* single teeth which are sound are usually of great importance. They should not be removed, as they assist in retaining a denture by means of clasps or other devices. Especially is this true in persons advanced in years, as then the alveolar process is generally much absorbed. If the lower process is much absorbed, even an imperfect tooth will do good service of this character for a time; and if it is the first plate the patient has worn it will serve a good purpose by assisting in the retention of the plate until the patient has become accustomed to it, after which the tooth, if giving trouble, or if it is unsightly, may be removed and an artificial one placed on the plate.

Fig. 573



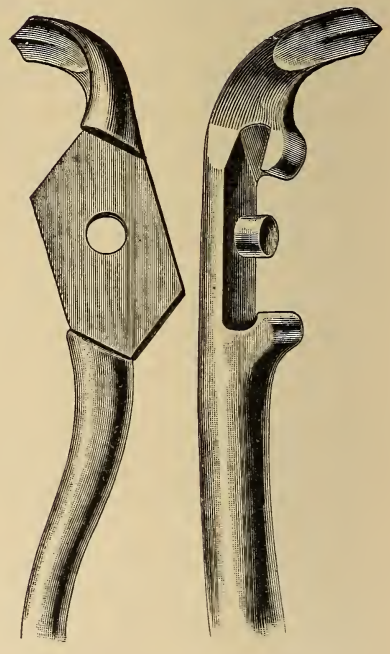
Antiseptic universal lower molar forceps.

INSTRUMENTS AND ACCESSORIES FOR EXTRACTING

The instruments used in extracting teeth are forceps and elevators of various shapes and sizes.

Forceps.—The forceps should be made of steel of the best quality for the purpose obtainable, in order to give great strength and stiffness and at the same time toughness, so that they will not break. Forceps that will spring or bend destroy the sensitivity of the hand using them in such a way as to prevent the operator from discerning in what direction the resistance to extraction is being made. The beaks of the forceps as a general principle

Fig. 574

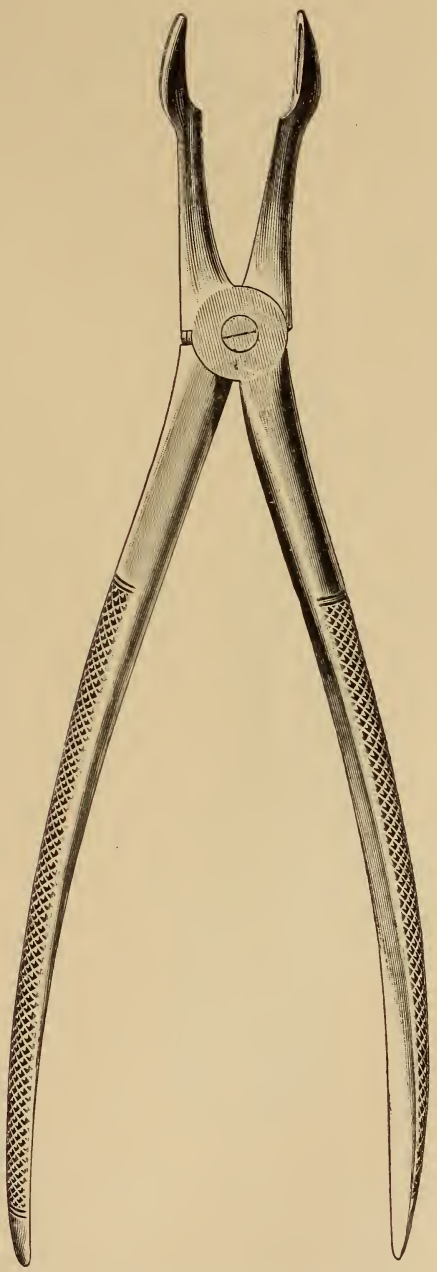


Joint of an antiseptic lower molar forceps.

should be shaped so as to fit and adjust themselves to as great a surface of the various teeth or roots as possible, so that they may take a firm hold. They should be at such an angle in relation to the handles as will permit them to be easily and readily placed in the proper position without obscuring the view of the tooth to be extracted. The inner surface of each beak should be concave in a transverse section and without serrations, as these are of no assistance, but tend to weaken the beaks and are difficult to clean. The edges of the concave portion should be sharp enough to cut through the alveolar process if necessary. The points of the beaks should be sharp and tapering so they can be forced into position. The handles should be of a shape to allow a firm grasp, and as the hands of different operators vary in shape and size it will be evident that the same size of forceps handles will not be perfectly satisfactory to all. The curvature of the handles should vary according to the general or special use of the forceps. The curved ends, as seen in Fig. 573, are of little use, and should be done away with in all forceps excepting perhaps those made especially for the upper and lower molars.

The joints of extracting instruments should be so made that the handles can be separated by some simple mechanism to permit of thorough and easy cleansing. Figs. 573 and 574 represent an instrument of this character. There are others of the same nature, but this being the most simple and the strongest should

Fig. 575



Knuckle-joint root forceps.

be generally adopted unless a similar device can be adapted to the "knuckle-jointed" instrument (Fig. 575).

There should be no sharp angles or crevices, and if the ordinary forceps be used, that portion around the joint in a transverse section should be oval. Forceps are often made with octagonal joints, but these should be condemned, as they may not only hurt the lips of the patient, but in case of a slip, which may happen with the best operators, they are more liable to cause injury by striking the other teeth; moreover, they are very clumsy and require more room.

Unless the antiseptic joint (Figs. 573 and 574) is used the union of the joints is usually made upon one of two principles: First, by one-half passing into a mortise in the other and held in the centre by a pinion (Fig. 576). The second is known as a knuckle-joint (Fig. 575) made by each portion being let half-way into the other and held together by a screw. This is a neater joint and does away with many of the objectional features noted in other forms of forceps joint.

All handles should be serrated, as shown in the illustrations, and the instruments if properly cared for need not be nickel-plated. The number of forceps in a practical set will vary with the requirements of every individual who extracts teeth, therefore only the general principles which should govern the selection of a set of instruments will be here given; at the same time the uselessness of a very large selection is here emphasized. As an illustration of the range of tooth extractions which may be performed with a limited number of instruments, the forceps represented by Figs. 576 and 577, showing the exact size, will serve as examples. They are smaller than the ones generally used, especially in America.

The instruments shown in Fig. 576 may be used almost universally for the upper teeth.

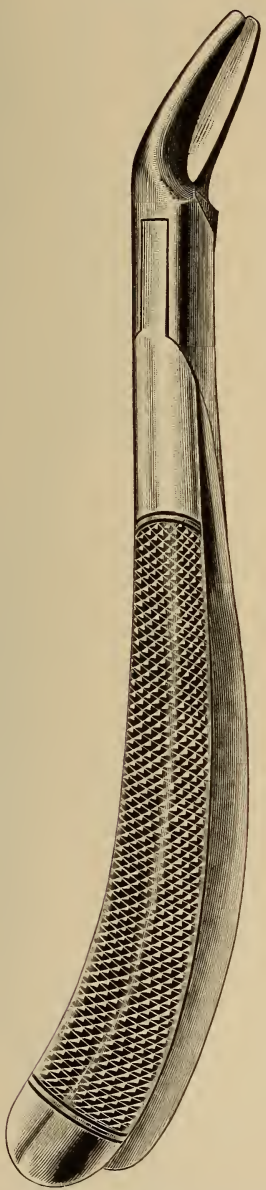
Fig. 577 is a forceps of the same general character as that in Fig. 576, only the beaks are at a different angle with the handles. This pair may be used similarly for the lower teeth. These forceps are useful in all cases, except in the full arch, when either a first or second molar is to be extracted. If the teeth are large, the jaw strong, and the line of grinding surfaces concave, it is better to use the special lower molar forceps as shown in Figs. 573 and 586.

Figs. 578 and 579 represent very useful forceps for extracting the ten upper anterior teeth. Fig. 579 has longer beaks and its points are finer. In skilful hands where too great a force will not be brought to bear on the points they are the better forceps. Under nitrous oxid and where many teeth are to be extracted, thus requiring rapid work, the instrument shown in Fig. 578 is preferable.

Figs. 580 and 581, right and left, represent forceps specially used for extracting the first and second upper molars on either side. The outer beak is made pointed for the purpose of passing in between the buccal

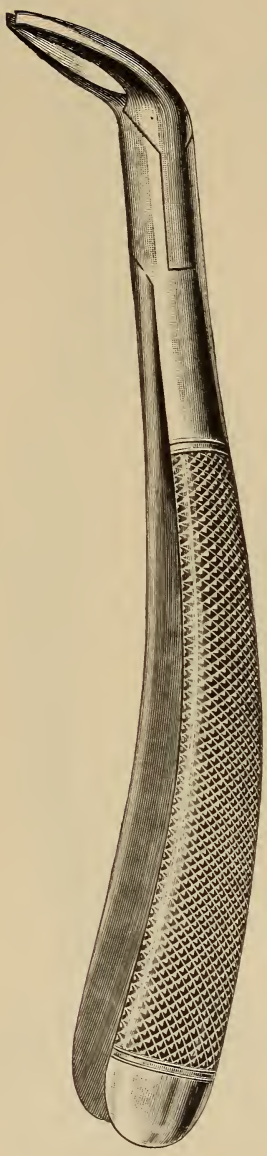
roots, the inner beak is concave in order to grasp the palatal root. Figs. 583 and 584 show bayonet-shaped forceps, that illustrated by Fig. 583

Fig. 576



Universal upper incisor and root forceps.

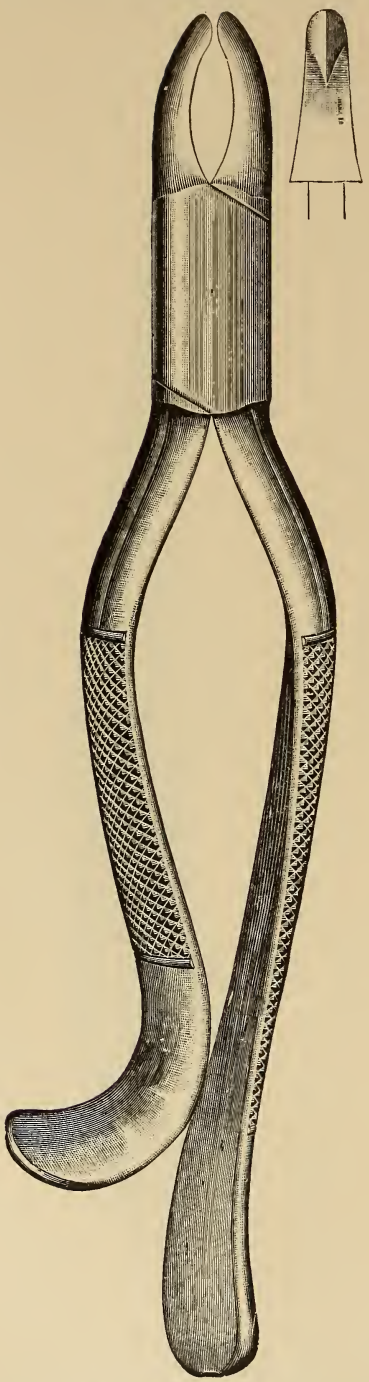
Fig. 577



Universal lower incisor and root forceps.

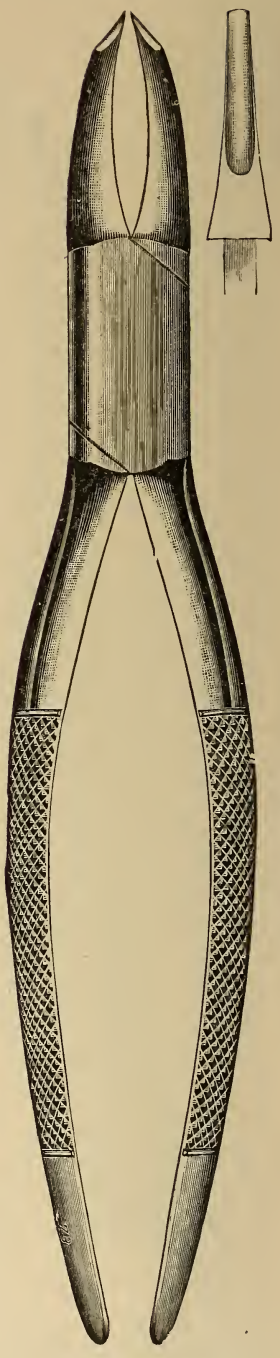
being specially made for extracting the upper third molars, Fig. 584 being used for upper roots. The ends of the handles of all forceps which

Fig. 578



For the ten upper anterior teeth.

Fig. 579



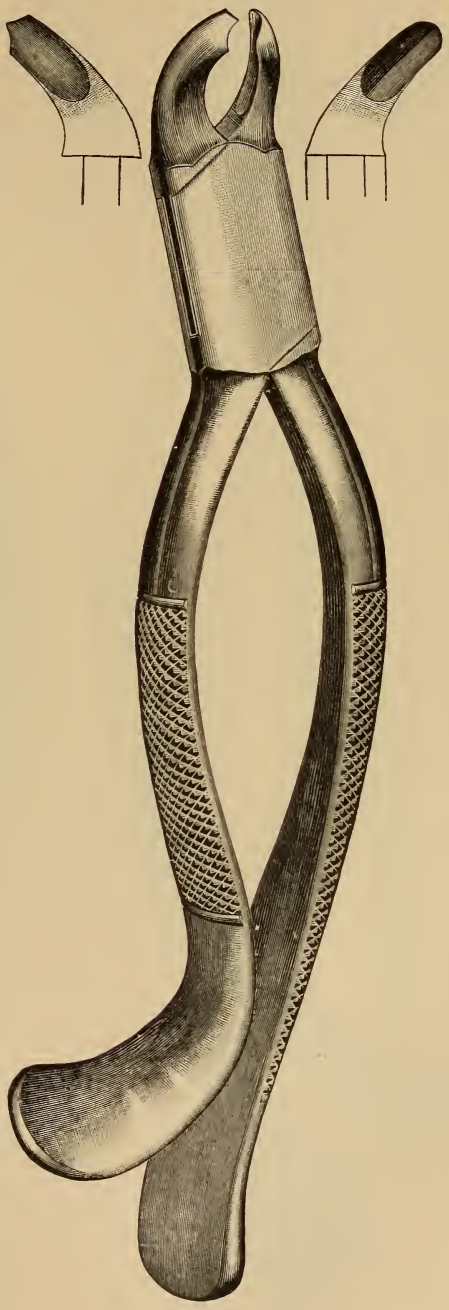
Root, upper front (straight).

are forced in by the palm of the hand should have a broad surface, as shown in Fig. 584. These forceps are popular with many operators. The writer considers them clumsy, as they obscure the proper view of the tooth and its associated parts.

Forceps for Extracting Lower Teeth.—Instead of the beaks of the forceps being nearly on a line with the handles, as in those for the upper jaw, they are bent at nearly a right angle. For the incisors of the lower jaw there are no better forceps than those shown in Fig. 577. This instrument is very useful in extracting the lower third molar when fixation of the jaw from diffuse cellulitis in the region of the temporomaxillary articulation renders it difficult to open the mouth sufficiently for inserting a larger instrument. In such cases the forceps should be carried backward in the vestibule of the mouth with the inner beak passing between the upper and lower teeth; when the beaks reach the third molar the inner beak can usually be forced over the inner surface of the tooth and into position, after which the tooth can be grasped and extracted. The forceps represented in Fig. 576 can also be used to advantage for these teeth, the operator standing behind and working over the head of the patient, as shown in Fig. 639.

Fig. 582 exhibits a hawk-beaked forceps for extracting the anterior lower teeth. It is very popular with some oper-

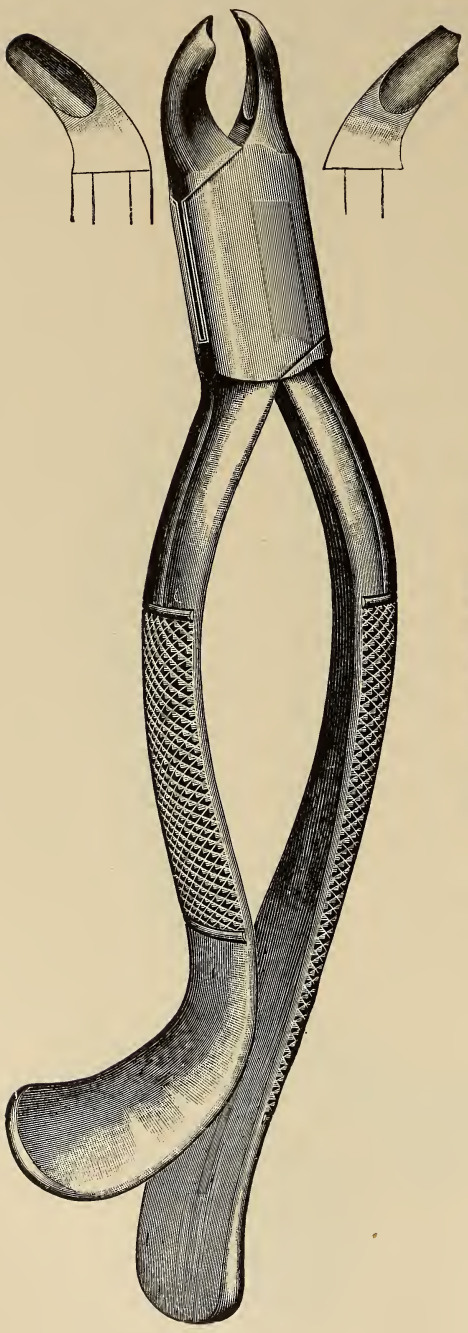
Fig. 580



Right upper molar.

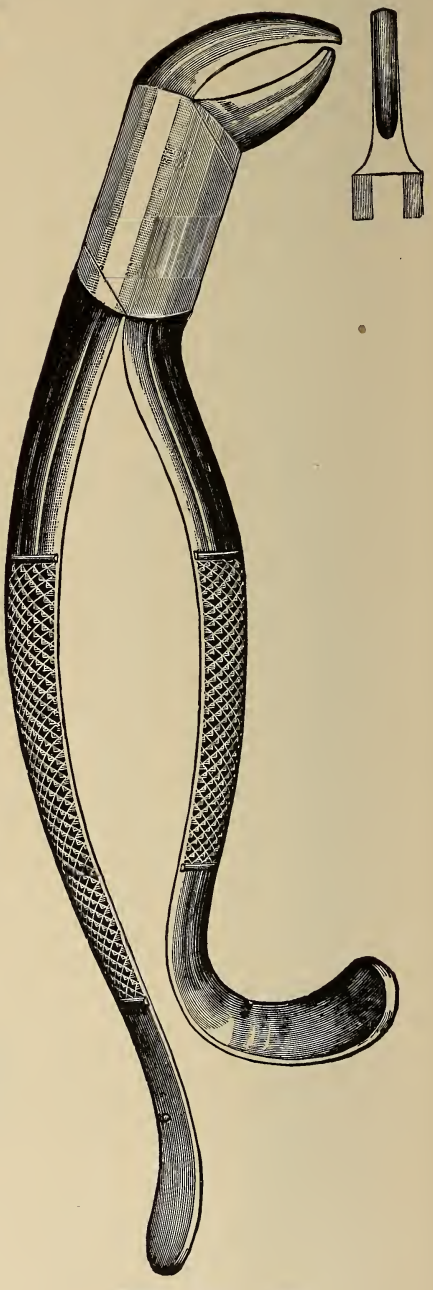
ators, especially those in Europe. The writer does not recommend it. Fig. 585 also exhibits a special instrument. It is made for extracting

Fig. 581



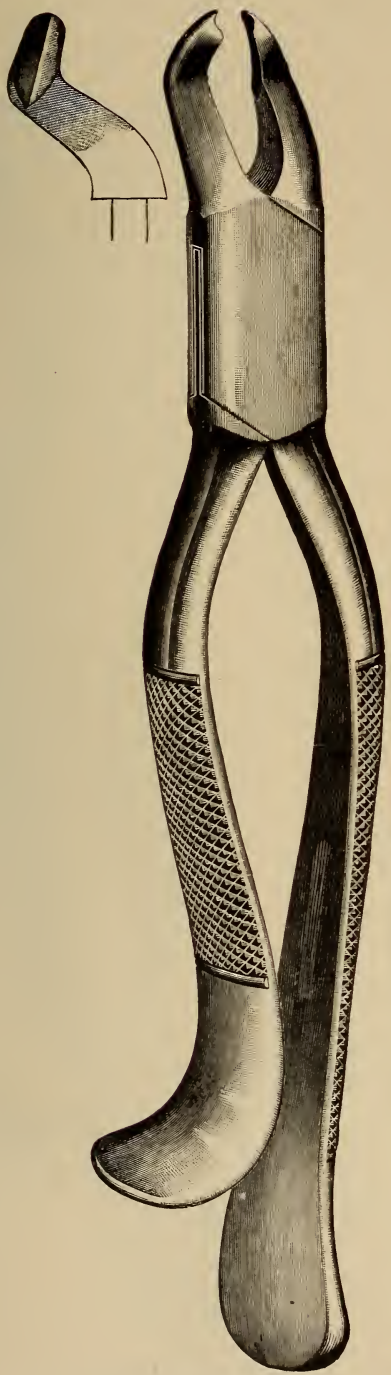
Left upper molar.

Fig. 582



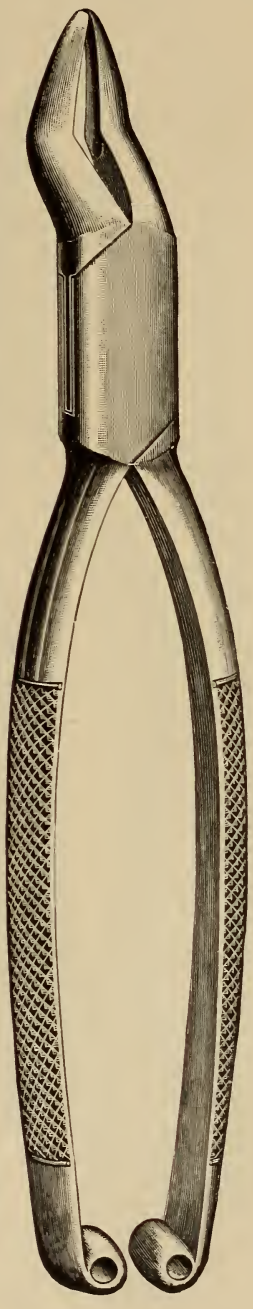
Hawk-beaked forceps.

Fig. 583



Universal upper third molar.

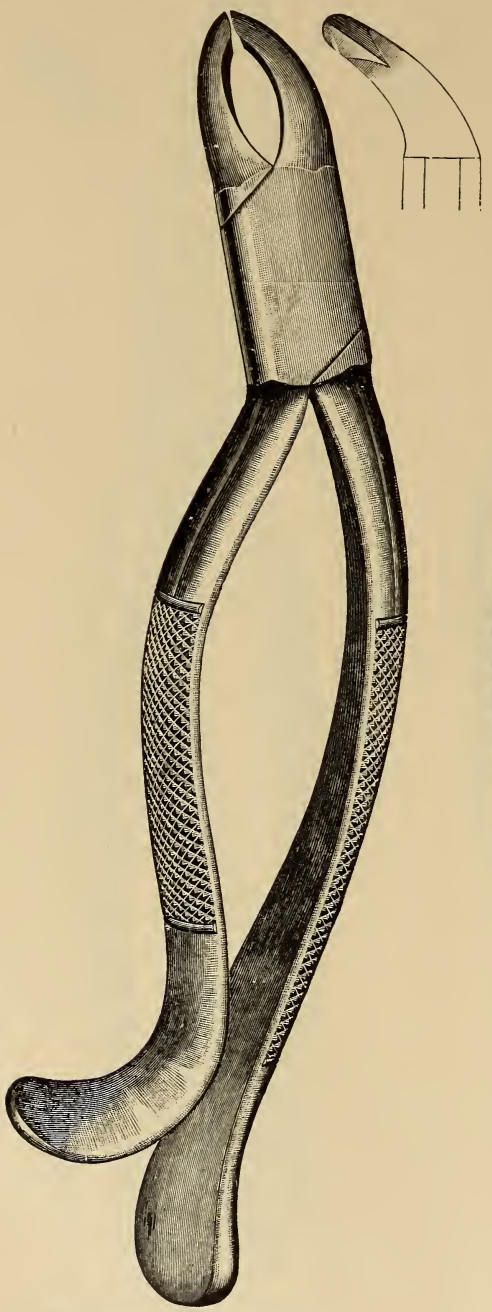
Fig. 584



Dorr's upper root forceps.

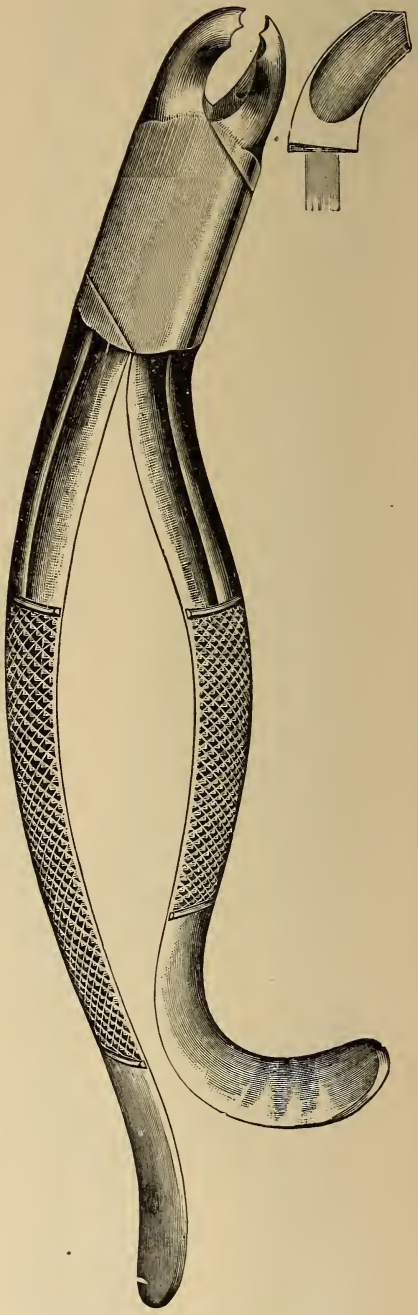
the lower canine and bicuspid teeth of either side. Fig. 586 is a special instrument used for the lower molars of either side. The beaks

Fig. 585



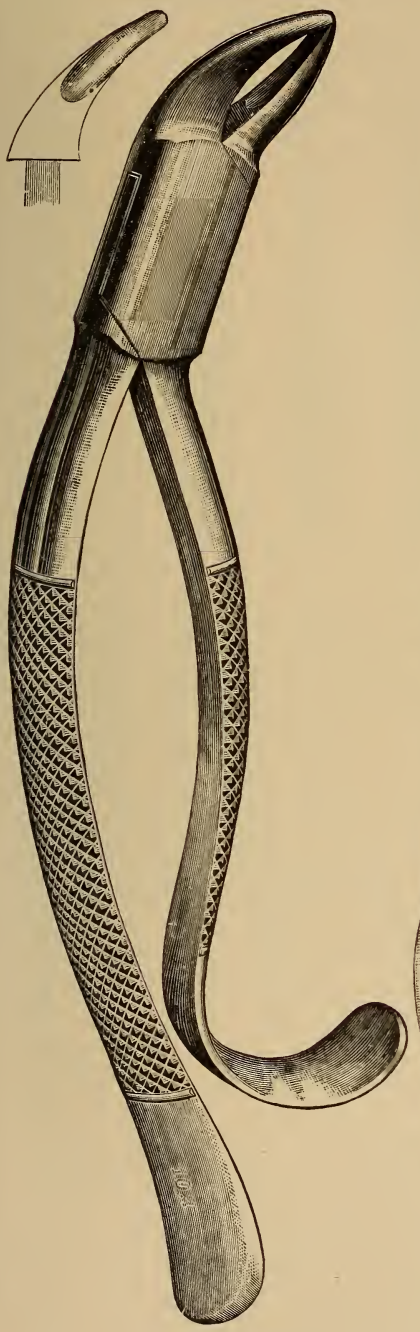
Universal lower canines and bicuspids.

Fig. 586



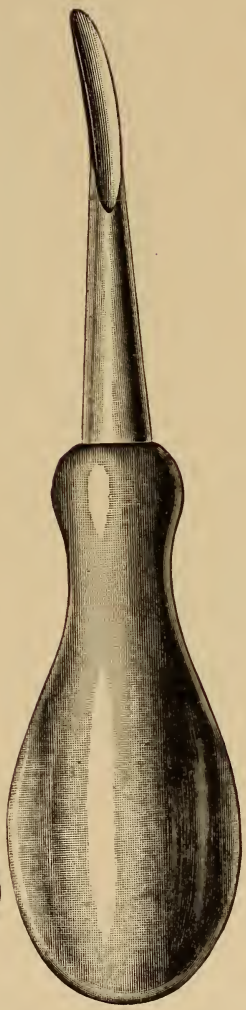
Universal lower molars, designed by Dr. Chapin A. Harris.

Fig. 587



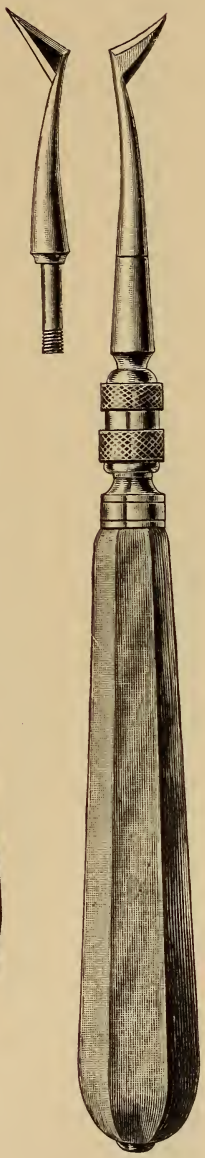
Root, lower. Half curved.

Fig. 588



Elevator.

Fig. 589



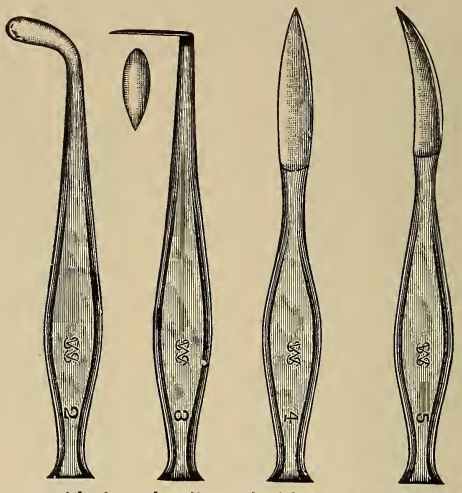
Right and left scalers used for extracting roots.

are pointed, with a concavity on each side of the point to allow it to pass in between the roots. The two concave portions fit against each root.

Fig. 590



Fig. 591



Lancets with ebony handles and with solid steel handles.

Fig. 587 represents a universal lower root forceps which is preferred by many to that shown by Fig. 585.

Elevators or Root Extractors.—There are many kinds of elevators used in extracting roots. Some are also occasionally used in the extraction of teeth (usually the third molar).

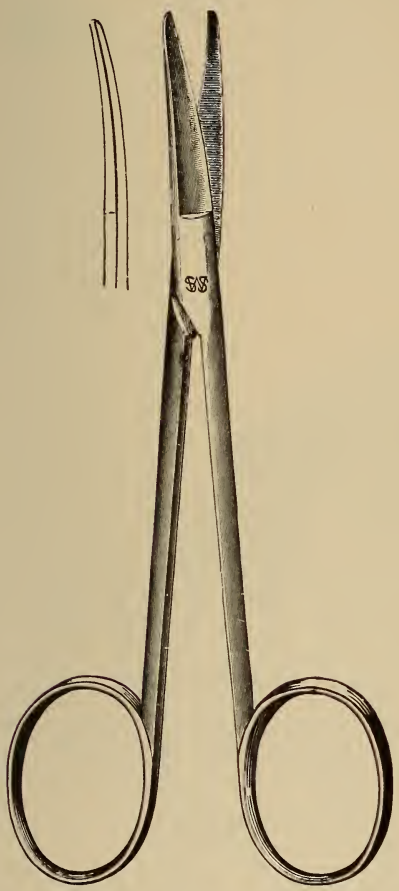
Fig. 588 shows one of the most useful forms of this instrument. It is especially useful in extracting third molars when the teeth in front of them are in position. Also for the removal of impacted teeth by passing in between the impacted tooth and an adjoining tooth, or between the tooth and the bone, the concave portion being placed against the tooth to be removed. It is also useful as a gouge at times in removing bone that is overlying an impacted tooth.

Fig. 589 represents two elevators; they are similar to right and left scalers, being made somewhat heavier; they are extremely useful in extracting roots. They are so unlike an extracting instrument that patients do not dread the appearance of them as they do that of forceps. By carefully inserting the blade with the point toward the root to be removed, between it and the adjoining root or tooth, and giving a slight rotary motion, the point will force the root from its socket with but little pain.

Figs. 630 and 631 illustrate two other forms of elevator, with their mode of application in the removal of roots.

Lancets.—Figs. 590 and 591 represent various forms of lancets, the more useful of which are Nos. 1 and 5, which are all that are required for lancing in extracting or for relief of retarded eruption of deciduous or other teeth. They are also useful in general surgery of the mouth. The handles should be made of metal instead of wood, in order that they may be thoroughly sterilized.

Fig. 592



Curved scissors.

Scissors.—A good pair of curved scissors, as shown in Fig. 592, should be at hand in case a portion of gum tissue is found to be attached to the root. If the scissors were slightly more curved they would be even better adapted for this purpose.

In connection with the instruments already mentioned, there should be a *mouth mirror* (Fig. 593) and a few 45 degree angle hatchet-shaped *excavators* and *probes* for general examination of the teeth, especially for examining the position and character of a root or impacted tooth which it is purposed to extract.

Fig. 593



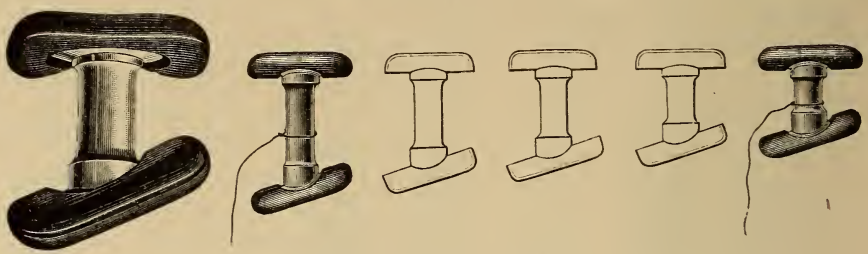
Mouth mirror.

Mouth Props.—When an anesthetic is to be given it is advisable to use some kind of a mouth prop, in order to keep the mouth well open. Corks $1\frac{1}{2}$ inches in length, $1\frac{1}{4}$ inches at the base, and $\frac{3}{4}$ of an inch at the small end are very useful for this purpose when placed between the jaws, with the small end in the mouth. Some operators do not use them, as they may interfere with the giving of the anesthetic by impeding respiration upon beginning the administration. The majority of patients,

if asked to hold the mouth open while taking the anesthetic, especially nitrous oxid and oxygen, will keep it open during the anesthetic stage.

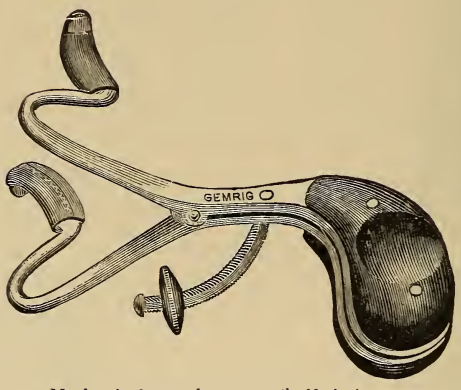
Fig. 594 illustrates excellent props devised by Dr. Frederic Hewitt, of London, England.

Fig. 594



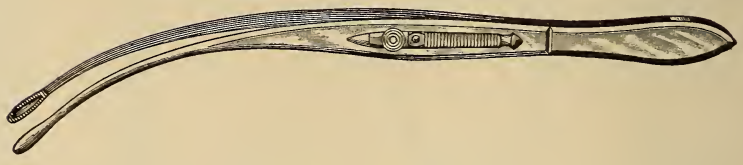
Hewitt's mouth props (half size).

Fig. 595



Mechanical mouth-opener (half size).

Fig. 596



Pharyngeal forceps (half size).

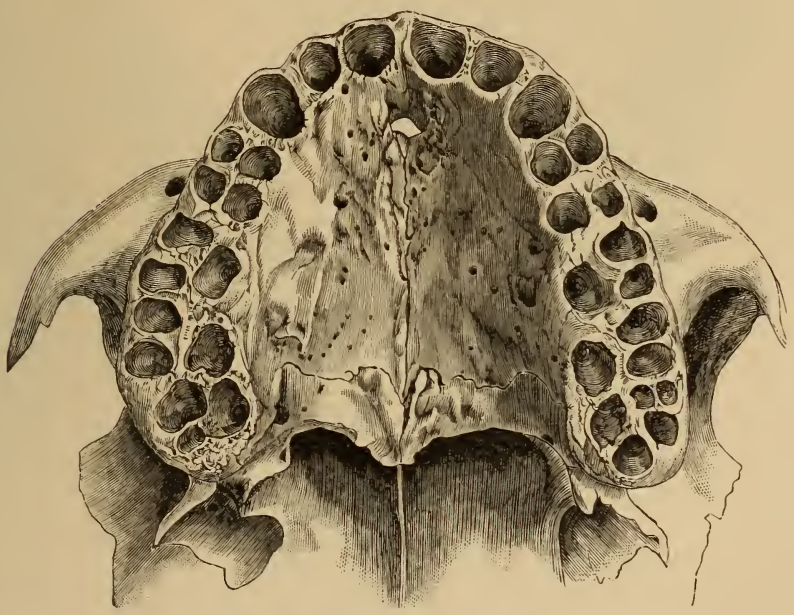
The Mechanical Mouth-opener (Fig. 595).—This instrument is made in various shapes and sizes. It is inserted between the jaws when the props are to be removed or in cases of trismus, and may also be used to separate the jaws and retain them so in cases of emergency or during certain operations within the oral cavity.

All dentists, and especially those who extract teeth, should have at least one pair of pharyngeal forceps (Fig. 596). It is possible that they may never be used, but on the other hand an accident may occur such as

a fragment or tooth slipping into the pharynx, where if the finger cannot reach it this instrument will be absolutely necessary.

Surgical Anatomy.—To extract teeth successfully it is first necessary to be perfectly familar with the general shapes of the different teeth and their position in relation to the jaw and to their associates, in order that the operator may intelligently apply the force in the line of the least resistance required for their removal. This knowledge cannot be obtained from books; they are but the guides to it. The jaws of the dead subject must be dissected—both the cleaned bones and those with the soft tissues left upon them. "Dissection" means that not only shall the superficial relations be studied, but that the bones shall be cut in various directions, both with the saw and other instruments, until the relations of the teeth of the upper jaw with the floor of the nasal chamber and the maxillary sinus are fully understood. In the lower jaw the relations of the teeth with the inferior dental canal and the position of the roots, especially those of the third molar, must also be thoroughly known.

FIG. 597



Alveoli of permanent teeth (upper jaw).

The alveolar process of both jaws is made up of two plates, external and internal, consisting of dense compact bone without a true line of demarcation between the process and maxilla proper. The sockets for the roots of the teeth are situated in the interspaces between these plates and are surrounded by a very thin porous plate of cortical bone. The remaining space is filled with cancellated tissue, small bony channels,

connective tissue, nerves, vessels, etc. As this process belongs to the teeth, is developed with them, and is for the purpose of holding them in position, it disappears to a greater or less extent when the teeth are lost. The resorption of this process does not take place alike in each jaw. In the upper jaw the external plate disappears more rapidly and to a greater degree than the inner plate; in the lower jaw the resorption of the two plates is about equal in extent and rate. The inner plate of the upper jaw is partially supported by the external plate of the palatal process; in fact, one merges into the other. The outer alveolar plate of the upper jaw being resorbed to a greater extent than the inner one is of advantage

FIG. 598



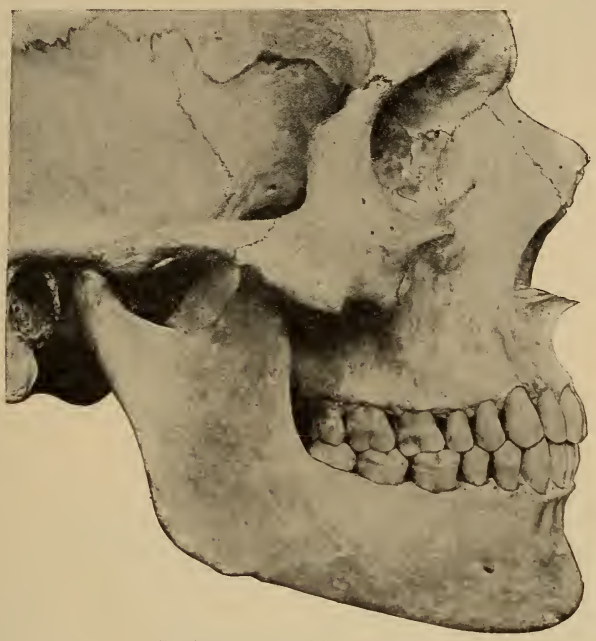
Alveoli of permanent teeth (lower jaw).

to the dentist in fitting teeth to the gums; consequently, in extraction that fact should be remembered and injury to the internal plate avoided. At the same time it does no harm to remove a small portion of the outer plate, though loss of the gum tissue should be avoided if possible. In the lower jaw it is not so important to avoid removing slight portions of the inner plate, as resorption takes place about equally in the two plates.

These plates may be resorbed in such a manner that a slight ridge is left between the places which they occupied. This resorption of

both plates of the alveolar process of the lower jaw makes it more difficult to fit single plain teeth in the lower than in the upper jaw.

Fig. 599



Typical upper and lower jaw.

Fig. 600



Showing the occlusal surfaces of the upper teeth. (From same skull as Fig. 599.)

Fig. 597 shows the alveoli of the upper denture, Fig. 598 that of the lower.

FIG. 601



Showing occlusal surfaces of the lower teeth. (From same skull as Fig. 599.)

FIG. 602



Showing the buccal surfaces of the crowns and roots in position.

Fig. 599 illustrates a typical upper and lower jaw, the external surfaces of the crowns of the teeth, also a normal occlusion. Figs. 600 and 601 illustrate the occluding surfaces of the teeth and their relations with each other. They are made from the same skull as Fig. 599.

Fig. 602 is from a photograph taken from the right side of a skull. It gives a good representation of a fairly normal occlusion of the teeth, their shape, roots, and their relation with the cancellated tissue and the inferior dental canal or cribriform tube of the lower maxilla. In the upper jaw the bone is thin over the position of the molar teeth, and their roots are comparatively straight; none of these should be difficult to extract. The buccal roots of the first molar are somewhat divergent from each other. The same roots of the second molar spread only slightly, as they leave the crown and close in at the points. The roots

Fig. 603



From the same jaw as Fig. 602.

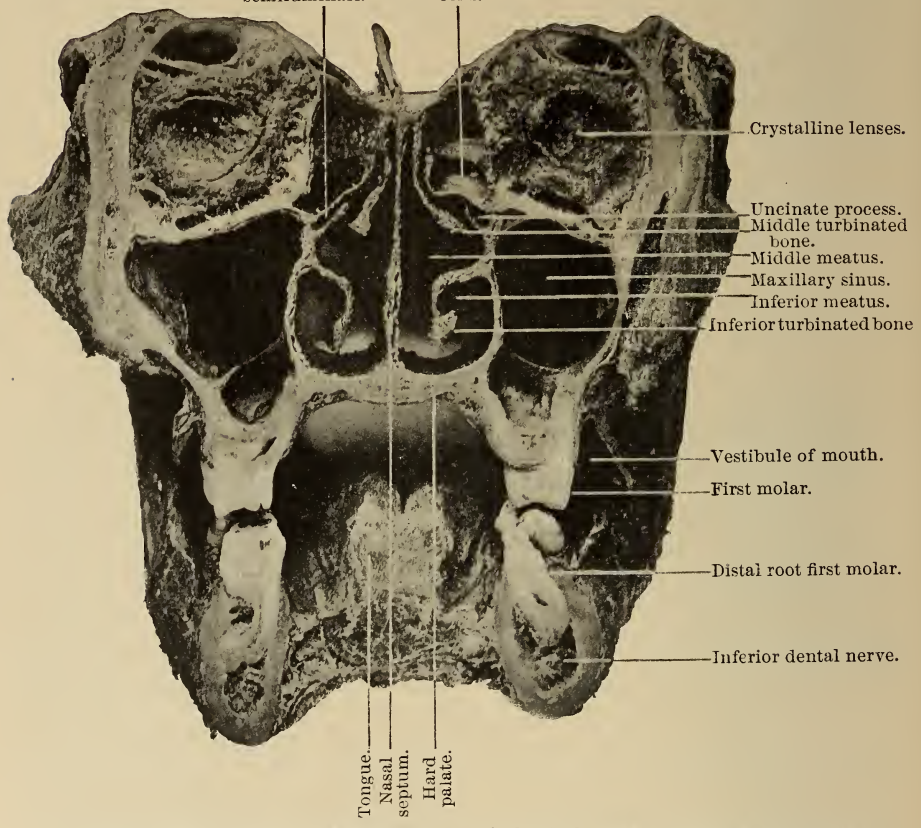
of the third molar are together and slightly curved backward. In the lower jaw the roots are comparatively straight. Those of the first molar are spread only a little apart, this being the usual condition. The roots of the second molar are almost straight and are nearly parallel with each other. The anterior root of the third molar curves slightly backward until it joins the posterior root.

Fig. 603 is taken from the left side of the same jaw as Fig. 602. In Fig. 602 the roots have been exposed down to their apices; in Fig. 603 only the external or cortical plate has been removed. These two illustrations give a correct idea of the relations of the teeth to the internal structures of the jaw.

Figs. 604 and 605 are good illustrations of the relations of the roots with the floor of the maxillary sinus usually found in the white race.

In the negro there is usually a considerable thickness between the teeth and the floor of the sinus. It will be noticed that the roots of the molars pass up on both sides of the sinus, and because of this fact it is necessary in extracting teeth from a jaw of this character to use the greatest caution, otherwise a portion of the floor of that cavity might also be removed. Or if a tooth be broken and much upward force used

FIG. 604



An anterior view of a vertical transverse section of the head, showing the relations of the jaws and the U-shaped bone of the mandible.

in endeavoring to take hold of the root, the latter could easily be forced into the sinus. The lower portion of Fig. 604 gives a general idea of a transverse section of the lower jaw made posterior to the mental foramen. Special attention is drawn to the U-shaped formation of the cortical portion of the lower jaw which terminates in the two plates of the alveolar process, and between which the roots are embedded in the cancellated tissue. It also shows how the roots extend toward the

inferior dental nerve. There is no line of demarcation between the alveolar process and the body of the bone.

Fig. 605



Posterior view of vertical transverse section of the head from the same skull as Fig. 604, showing the ostium maxillare, which is indicated on each side by a cord passing through it: *Om*, ostium maxillare; 1*st* M, first molar.

Fig. 606 shows the relation, length, and position of the second bicuspid, showing that its root is sometimes placed to the inner side of the anterior root of the first molar. The roots of these bicuspids are flat, as

Fig. 606



Ar 1*st M*, anterior root of first molar; *R 2d Bi*, root of second bicuspid; *Idn*, inferior dental nerve; *Up*, U-shaped or cortical section of lower jaw.

will be seen by looking at Fig. 626. On taking into consideration their length, position, and thinness it will be readily seen why it is so often difficult to extract them without breaking.

Fig. 607 is taken from horizontal sections of the lower and upper jaws, showing the transverse sections of the roots of the teeth. The section is made a little above the margin of the alveolar process of the upper jaw and a little below in the lower. The illustration shows the

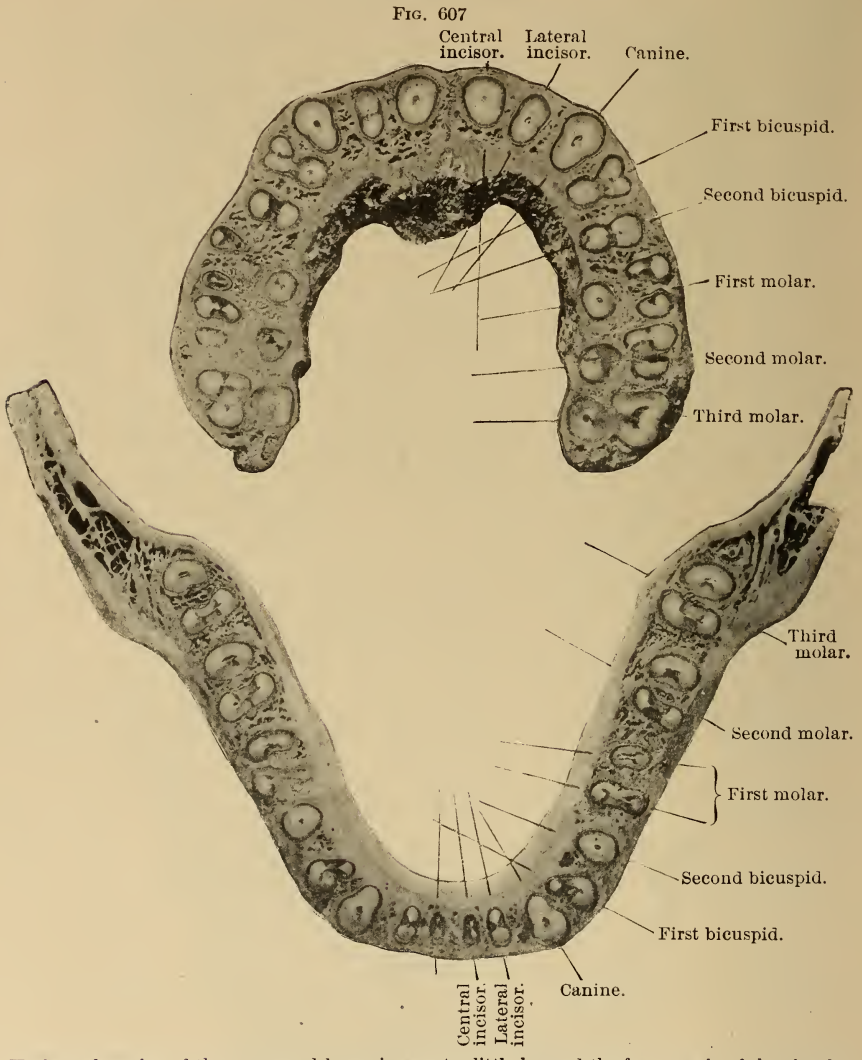


FIG. 607

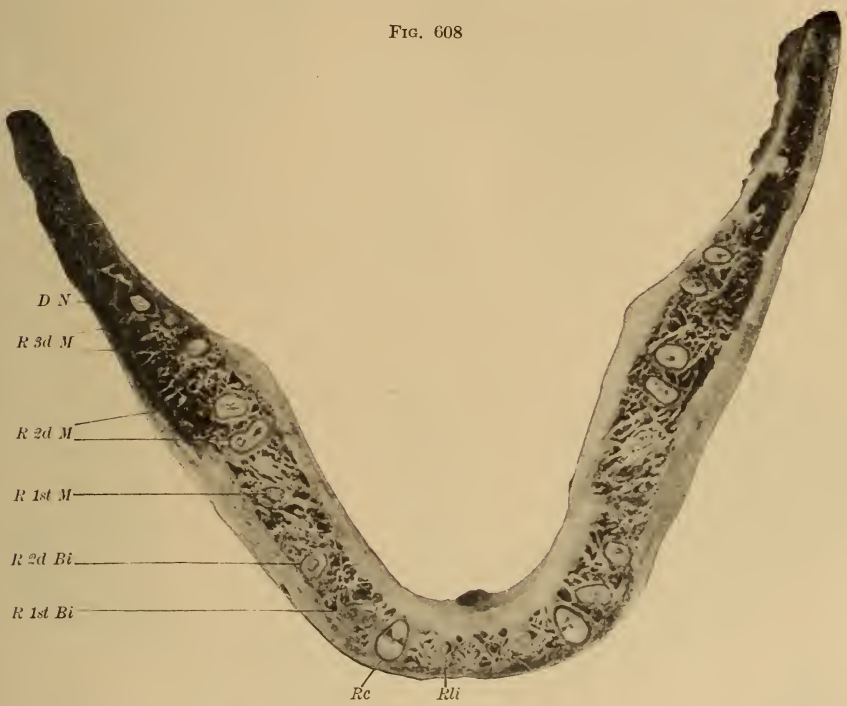
Horizontal section of the upper and lower jaws cut a little beyond the free margin of the alveolar process, showing the forms and position of the roots of the various teeth.

shape and position of the various roots, with their relations to the process and to each other. Particular attention should be given to the fact that the roots and process are in such close relation as to make it impossible to force the beak of a forceps between them without breaking one or both plates of the process. The lines leading from the roots

show the proper direction for applying what is known in extracting as the "out-and-in motion."

Fig. 608 represents a horizontal section made through the lower jaw near the ends of the roots, and from the same bone as that shown in the lower half of Fig. 607. The cancellated portion with the soft tissue filling the spaces can be plainly seen. The nerve passing into its tube, the ends of the roots of the second and third molars, the tip of one of the roots of the first molar, and the roots of the first and second bicuspids are all plainly shown. A little of the lateral incisor can be noticed, but the centrals do not reach so far down.

FIG. 608

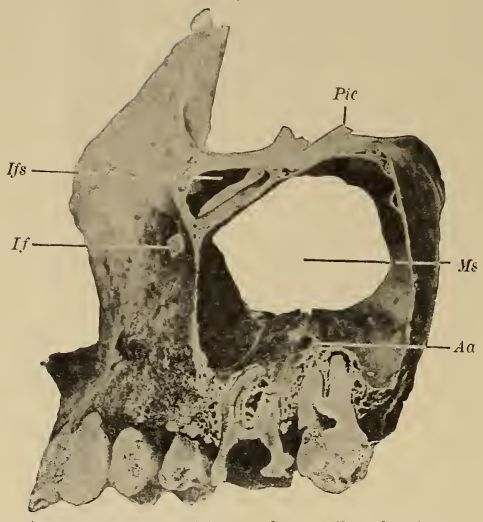


Horizontal section of the lower jaw cut in the region of the points of the roots of the teeth: *DN*, dental nerve; *R 3d M*, roots of third molar; *R 2d M*, roots of second molar; *R 1st M*, distal root of first molar; *R 2d Bi*, root of second bicuspid; *R 1st Bi*, root of first bicuspid; *Rc*, root of canine; *Rli*, root of right lateral incisor.

Figs. 609 and 610 are taken from a sagittal section of the upper jaw, external to the infraorbital foramen, and through the roots of the molar teeth. This illustration shows how the roots often extend above the lower portions of the floor of the sinus, an abscess from the palatal root of the first molar having discharged into the floor of the sinus at the point *Aa*.

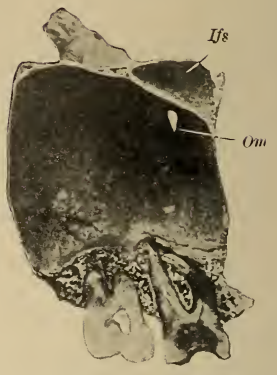
It has been demonstrated both anatomically and clinically that infectious matter from a suppurating tooth may eventually give rise to an inflammation of the meninges of the brain. Should pus form a dento-

FIG. 609



Anteroposterior division of the maxilla, showing opening of a dental abscess within the antrum and an infraorbital sinus: *Ifs*, infraorbital sinus; *If*, infraorbital foramen; *Pic*, piece of paper passing through infraorbital canal; *Ms*, maxillary sinus; *Ac*. apical abscess.

FIG. 610



Om, opening into malar bone; *Ifs*, infraorbital sinus.

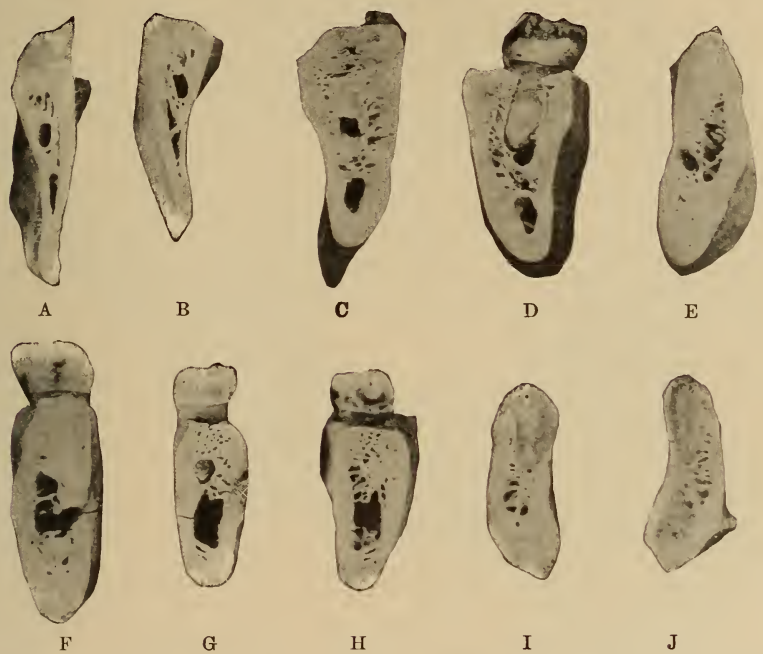
FIG. 611



Longitudinal division of a mandible, exposing the cancellated tissue in the body of the jaw and between the sockets of the teeth.

alveolar abscess discharge into the maxillary sinus it may pass out into the hiatus semilunaris and ascend into the frontal sinus or in the vicinity of the cribriform plate of the ethmoid through the infundibulum when the passage through the hiatus into the middle meatus is small or constricted, as it usually is when inflamed, or the pus may pass directly through the infundibulum. Recent research has shown that the frontal sinus, the cribriform plate of the ethmoid, and the meninges of the brain are in close relation at the anterior portion of the cribriform plate, a diseased condition at which point is liable to involve all three structures.

FIG. 612



Sections made at different points from a mandible which was not quite normal in its density.

Fig. 611 is from a longitudinal section of the lower jaw, and gives a good idea of the cancellated tissue, the relations of the sockets of the teeth to one another, and the position of the inferior dental canal.

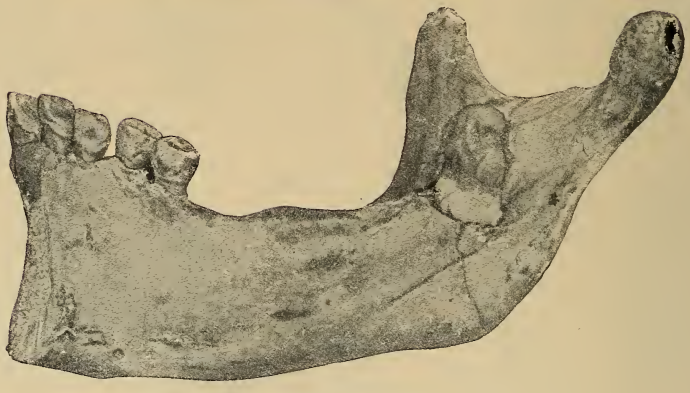
Fig. 612 is taken from several transverse sections of a lower jaw The bone is not quite normal, as several teeth were extracted before death, the loss having caused changes in the character of the bone. Some of the sections show but one canal, while in others there are many, requiring close observation to determine in which the inferior dental nerve and vessel have passed.

Fig. 613 is taken from the inner side of the right half of a lower jaw. The second molar has been broken off, the roots still remaining in position. The points of the roots of the third molar pass out through

FIG. 613

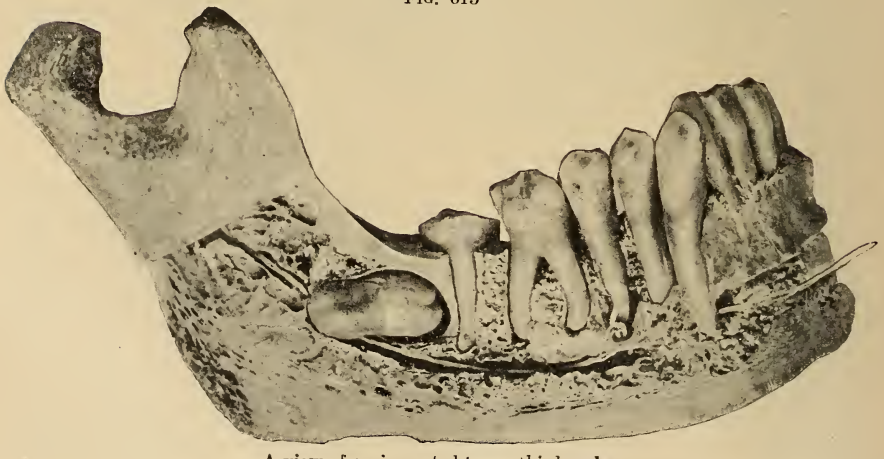


FIG. 614



An uncommon impacted lower third molar.

FIG. 615



A view of an impacted lower third molar.

the inner wall a considerable distance below the mylohyoid ridge. A portion of the ridge has been cut away, exposing the remainder of the internal surface of the roots. This will be further alluded to when extraction of the lower third molar is considered.

FIG. 616



A second view of an impacted lower third molar, as shown in Fig. 615. Part of the distal root of the second molar has been resorbed, exposing the root canal, more than likely causing the devitalization of the pulp, and thus producing neuralgia.

FIG. 617



Inner side of left half of lower jaw, showing an impacted third molar.

Figs. 615 and 616 are from the outer side of the right half of a lower jaw, Fig. 615 showing an impacted third molar lying horizontally in

the jaw. Fig. 616 is of the same jaw with the tooth removed from its bed, showing the inner surface. The second molar is a pulpless tooth the distal root of which shows where the impacted tooth has pressed

FIG. 618



Same as Fig. 617, with the impacted molar removed from his bed.

against it, causing the absorption of a portion of the root and exposing the pulp canal within, producing death of that organ. This must have

FIG. 619



Right half of lower jaw, showing a lower third molar with thickened and curved roots.

caused neuralgia. The cancellated tissue of this bone, it will be noticed, is not like that shown in Fig. 603, the change in the character of this tissue being the result of irritation. It will be seen that the roots of the

other teeth in this jaw are longer than usual, the canine tooth passing below the nerve and to the outer side.

FIG. 620



Left half of lower jaw, showing a third molar lying horizontally and the bone much more dense than normal.

Figs. 617 and 618 represent the inner side of the left half of a lower jaw. It shows an impacted third molar pointing slightly downward. The distal root of the second molar is slightly absorbed. On uncover-

FIG. 621



Showing two ordinary impacted lower third molars.

ing the tooth and taking it from its bed, it was found to be incased in a thin shell of bone, as though the dental sac had ossified separately around this tooth; this thin incasement of bone may, however, have been an

inflammatory product. The inner portion of this shell can be seen in position. The nerve and its accompanying tissue passes into the inferior dental foramen immediately against the shell, and has the appearance of being flattened out. It divides and sends a branch around the internal half of the shell.

Figs. 619 and 620 are taken from the right and left halves of the lower jaw. Fig. 619 shows the internal surface of the right half; Fig. 620 the external surface of the same. In Fig. 619 the roots of the third molar curve backward, are joined together, and are so enlarged

Fig 622



x-ray picture made from the left side of Fig. 621.

by an abnormal deposit of cementum, caused by continued hyperemia due to the prolonged irritation that the form of each root is lost; the bone also is much thickened. Fig. 620 shows an impacted tooth pressing directly against the one in front of it, the roots of which have become much enlarged by the deposit of cementum. The surrounding bone is also thickened and much more compact than the normal bone. The character of the cancellated tissue of the lower jaw is lost by the deposit of bone caused by continued irritation of that tissue.

Figs. 625 and 626 show the normal forms of the teeth, and Fig. 627

is taken from a group of abnormal teeth. If only normal conditions of the teeth had to be considered, as shown in Figs. 625 and 626, extrac-

FIG. 623



Side view of two ordinary impacted lower third molars, the bone having been removed in order to expose the roots.

FIG. 624



Showing an inverted lower third molar erupting into the submaxillary fossa. (Dr. Ottofy.)

tion would be a very simple operation, but unfortunately this is seldom the case. It often happens that even when the teeth themselves are normal they are situated in abnormal positions, and for this reason alone their extraction becomes necessary. In fact, so varied and com-

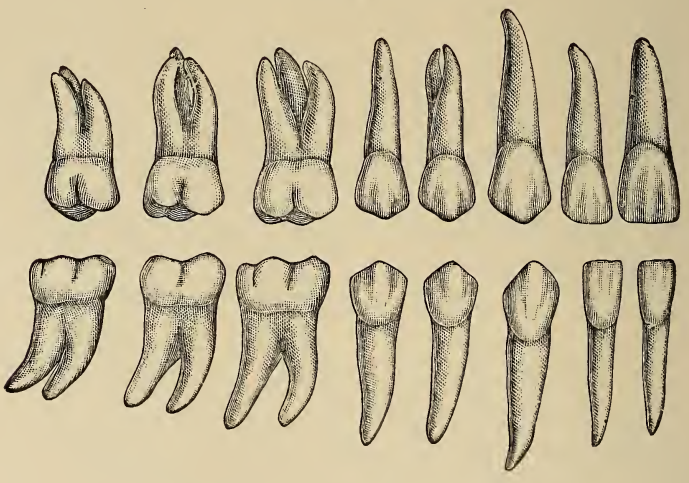
FIG. 625



Deciduous teeth—left side. (Burchard.)

plicated are the different abnormalities presented, that it would be impossible to describe them all. The diagnosis of unerupted teeth occupying abnormal positions has been greatly facilitated by special applications of the skiagraphic method. Its further use in this connection is but a question of time and development. A careful study of the com-

FIG. 626



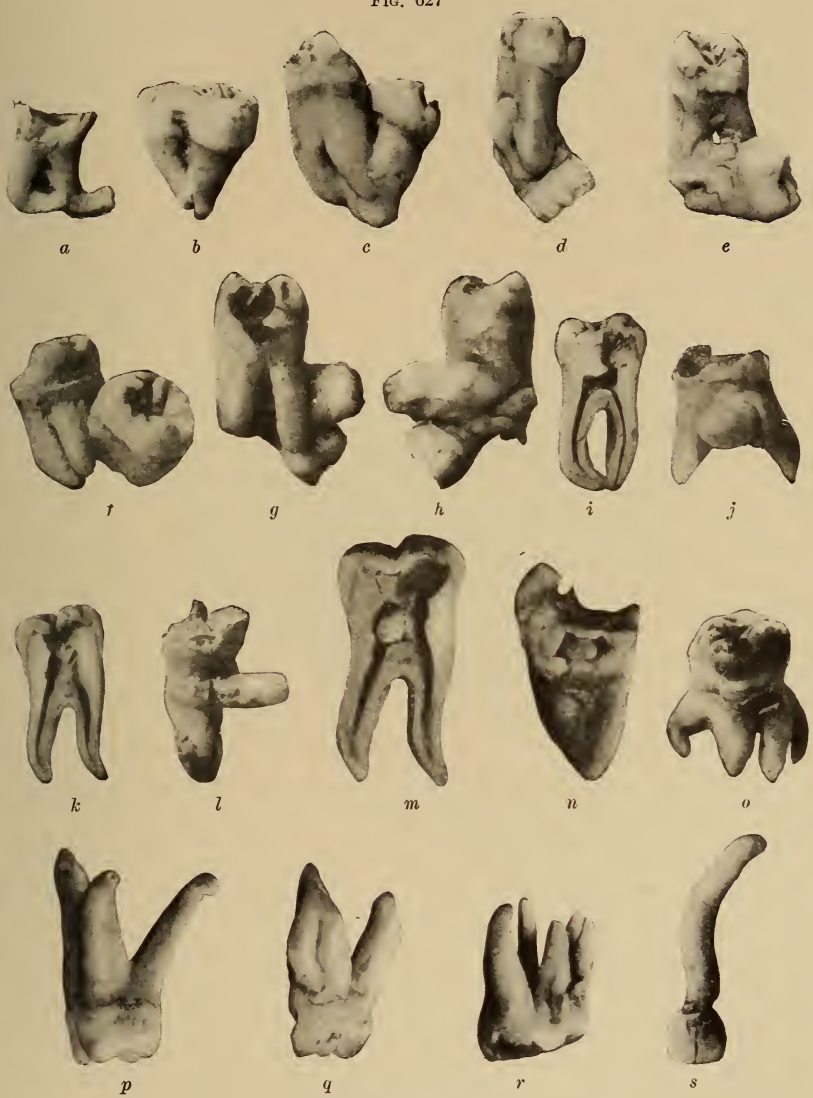
Permanent teeth—right side. (Burchard.)

plications most frequently occurring will, however, give good preparation for meeting the emergencies.

Figs. 613 to 624 and 628 show abnormal positions of various teeth. It will be readily seen that no set of rules could be made to govern the

extraction of these teeth; therefore only the general principles governing extraction can be here set forth.

Fig. 627



Abnormalities in teeth.

GENERAL PRINCIPLES IN EXTRACTING TEETH

These principles may be classified under the following heads:

1. Management and Position of Patients.
2. Selection of Instruments.
3. Technique of the Operation.

Managemant of Patients.—The first important step toward a successful operation in dentistry is to gain the confidence of the patient, who must be brought to rely entirely on the judgment and skill of the operator. If the operator feels entire confidence in his own ability to carry out successfully an operation, he can, by his manner of approaching the patient, impart a feeling of almost absolute trust in his skill. This feeling of confidence in himself should be cultivated, as it is evident that a slight nervousness on his part, even though he be most skilful, will tend to alarm the patient to such an extent as may cause great interference with the operation.

FIG. 628



Abnormal jaw showing impacted canines.

POSITION OF THE PATIENT.—The principal object to secure in placing the patient is to obtain a good view of the affected tooth and contiguous parts; after which the position should be made as comfortable as possible both for the patient and operator, taking care that the territory of operation can be reached with but little strain or effort.

The position both of patient and operator varies slightly for the extraction of each tooth. The main points to be observed are to have the particular tooth to be operated upon in view, and the head of the patient in such a position that it can be controlled by the left arm and hand.

The chair should be steady, strong, and comfortable, with arms and a good head-rest of rather a concave shape. It should also have a suitable foot-rest. (For further description of chair for anesthesia see page 613.) When the regular dental chair is not obtainable, an ordinary strong wooden chair can be used. If two of these chairs are placed back to back the extra one gives a good place for the left foot of the operator, and a head-rest may thus be made of his thigh. The patient

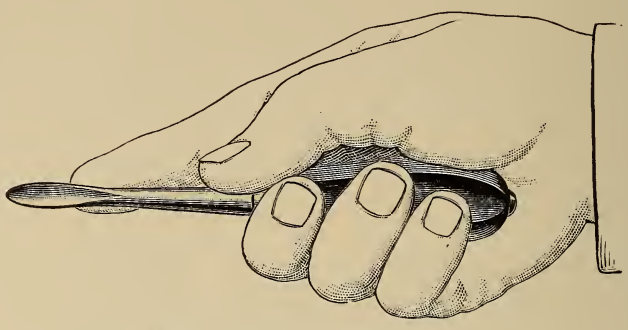
should be directed to grasp the seat at both sides with his hands. At times it may be necessary to extract while the patient is in bed or on an operating table; in such cases the operator must obtain the best position available. Where an operating table or couch is used it is well, if possible, to stand at the head of the couch or table and a little to one side of the patient. By reaching over the head, the forceps shown in Fig. 576 may be used to advantage in work on the lower jaw; the same forceps may be used for the upper jaw by standing to one side of the patient. If the operator is ambidextrous, so much the better, as it is very advantageous to be able to use the instrument in the left hand, especially in extracting the teeth of the right side of the lower jaw; the operator in this case standing on the left side. If, however, only the right hand can be used, the operator should, as a rule, stand at the right of the chair, the left arm and hand being used in various ways to control the head of the patient. The mouth is opened as far as necessary, and the left hand is then used to hold the lips away and keep the jaw as steady as possible. (See Figs. 636 and 637.) In using the elevator, as shown in Figs. 588 and 629, for the removal of teeth from the left side of the mouth, especially for the lower third molar, the operator should stand on the left side of the patient. The index finger of the right hand should be placed in the mouth by the lingual side of the tooth, and the thumb placed on the buccal side of the first and second molars. This gives steadiness to the jaw and lessens the risk of slipping.

Selection and Use of Instruments.—The selection of instruments depends on the nature of the operation to be performed. The means used in extraction should be of the most simple character. Many deciduous teeth and permanent teeth from about which most of the process has been resorbed can often be easily extracted with the thumb and finger. Children feel less apprehension with this method than when an instrument is used. The thumb and fingers should be covered with a napkin, and the thumb placed on the inner surface of the tooth with the fingers against the outside of the jaw. The tooth is then forced outwardly toward the cheek or lips. The roots of the deciduous teeth often break, but this is of little importance, for when extraction is demanded the roots are weakened by the natural process of resorption, and will soon disappear. Elevators of the various patterns shown in Figs. 588, 589, 629, 630, and 631 should be used whenever practicable for removing roots, and in some cases teeth also. Fig. 588 is especially useful in removing the third molars, especially if they be impacted. When the internal anatomy of the jaws is well understood, this will be appreciated.

Fig. 607 shows how firmly the roots are embraced at their necks between the two hard plates of compact tissue. It is usually impossible to force an instrument between the roots of teeth and these plates without breaking the internal or external walls of the latter. The cancellated tissue between these plates is, however, soft and yielding, and into

this a properly shaped elevator can be passed between the roots. After pushing the instrument with the point toward the root to be extracted and the back toward the contiguous tooth or root, using the latter as a fulcrum, revolve the elevator slightly, prying at the same time, and the

FIG. 629



Manner of holding elevator Fig. 600.

root will leave its socket with little or no injury to the surrounding tissue. Elevators should be firmly grasped and held in such a manner that if a breakage or slip should occur the instrument will be prevented from wounding the soft tissue. If root forceps were used in cases of this kind it would be almost impossible to avoid injuring one or the

FIG. 630

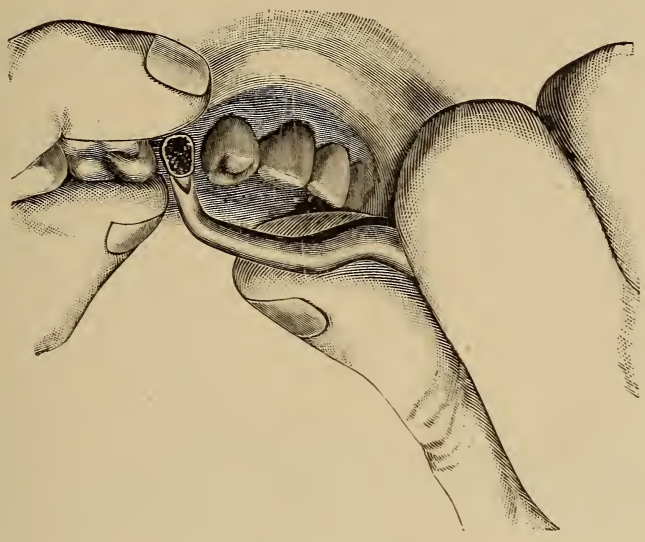


Elevator in use labially.

other of the plates when removing the root. It is often advisable to use the forceps by passing the beaks between the plates and grasping the root on its proximal surfaces, instead of the external and internal surfaces. Even whole teeth may be extracted in this way when there

are no adjoining teeth or roots. A similar plan is sometimes used in rapid extracting under nitrous oxid, where roots or teeth have been extracted on each side of a tooth, the beaks passing into the sockets of the extracted teeth, thus grasping the tooth to be removed on its proximal sides. This mode of operating must be followed with care, especially in teeth situated below the maxillary sinus, as the floor of that cavity may be easily injured. (See Figs. 604 and 605.)

Fig. 631



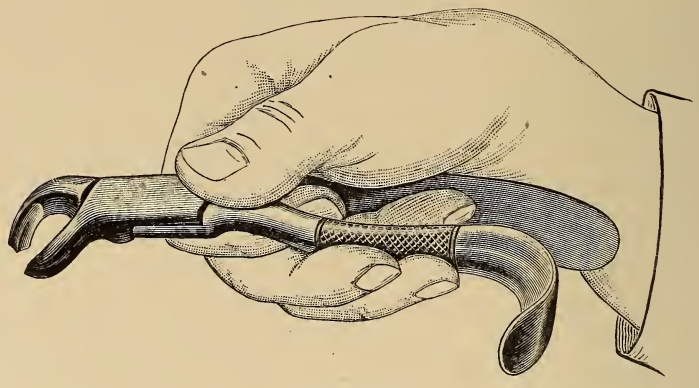
Elevator in use lingually.

Lancing.—Lancing for extraction is not usually required, although there are cases where it is quite necessary. If the teeth have been standing alone for a long time, especially those in the back part of the mouth, the gums are apt to become firmly attached to them; when this is the case it is well to sever the connecting tissue by the use of the lancet before extracting. In extracting roots where it is necessary to remove a portion of the external plate of the alveolar process, it is well to make an incision in a line over the root, through the gum to the bone; it is even advisable to dissect the gum and periosteum slightly from the bone on each side of the cut. This is done in order that the external beak of the forceps may be passed along the bone as far as desired. By thus lancing, the parts will afterward come together and heal quickly, whereas if the gum is cut by the forceps it will not heal so well. In extracting roots in the lower jaw, if the lancing would cause the blood to cover the parts and obscure the operator's view, it should be omitted.

Use of Forceps.—As nearly all operators are right-handed, the instruction as to the use of forceps will be given with that understanding,

most of the special instruments being made for that hand. The forceps are grasped in the right hand with the palm toward the body, the thumb on top of and partially between the handles (which will indicate to a great extent the amount of pressure being exerted upon the tooth), pressing against the handle nearest the palm just back of the joint. The first finger should rest a little between the handles, thus giving a firmer grip on the right handle (Fig. 632), which might be termed the fixed, or passive, handle; while the other one is the movable, or active, handle. Many operators do not place the first finger between the handles (Fig. 633). The second and third fingers pass to the outside of the left handle and are used to close the forceps, while the little finger resting between the handles is used to open the forceps, the thumb being used to force the beaks into the required position. After the forceps are in position for extracting, the first finger is placed along the side of the second finger to give more power to extract.

FIG. 632



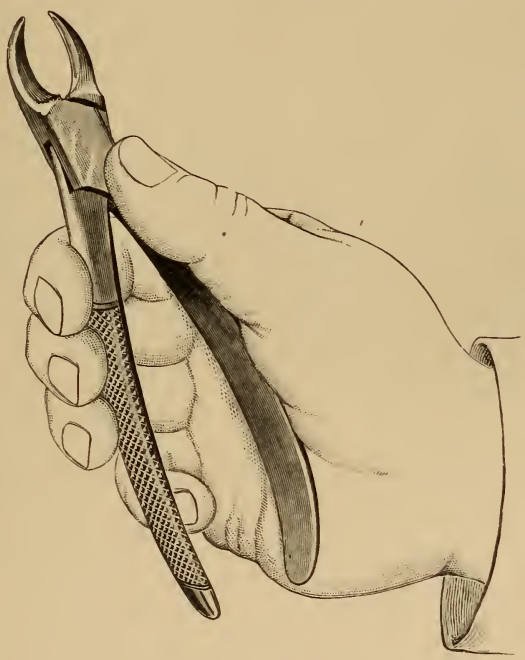
Use of forceps.

After it has been decided to extract by using the forceps, the particular forms indicated must be selected and arranged in a convenient place, ready for immediate use as needed. Especially should this be the case when the operation is done under the anesthetic influence of nitrous oxid. It is under such conditions that the fewer forceps used the better; the writer generally uses but one forceps (Fig. 577) for the extraction of any or all teeth except the first and second molars; for those teeth, when the other teeth are in position, he advises using the special forceps.

Having the patient's head in position, the forceps are grasped as previously described and the beaks adjusted to the tooth. As a rule, the inner beak should be placed in position first, and then the outer one—this is very important, especially for the lower teeth—taking care not to include a portion of the tongue or the soft tissues of the floor

of the mouth, as both are liable to get in the way. When the forceps are adjusted to the inner and outer surfaces of the tooth, they should be forced between it and the gum until they come in contact with the edge of the alveolar process. It is a common error of students to use too much force in pressing the handles together; only sufficient force should be used to hold the tooth or root securely. The forceps should grasp as much of the roots as possible, avoiding pressure upon the crown and being careful not to force the beaks between the alveolar plates, as this would result in breaking one or both plates over the tooth or root extracted and also over the adjoining tooth. Cases have occurred in which the entire external plate of one side has been forced off in this way.

Fig. 633



Use of forceps.

At times it may be advisable to take away a portion of the outer plate, in which case the lancet shown in Fig. 590 should be used to cut through the gum a little beyond the point of process to be removed, dissecting up the gum slightly; the inner beak is then adjusted and the outer one passed between the divided gum and the process as far as required; the forceps should then be closed with only sufficient force to cut through the bone and grasp the tooth, taking care not to crush it.

After the forceps are in position the tooth is loosened by rotating it slightly if it be a round conical-rooted tooth, such as a central incisor,

but if it be a flattened one it should be removed by an outward and inward movement.

By the "out-and-in motion" is meant that after the forceps are applied the force used in loosening teeth is directed in such a manner that the tooth is worked outward and inward from the median line of the mouth (see Fig. 607, in which the lines show the direction of the motion for each tooth). The individual teeth do not always bear the same relation to the median line of the jaw as shown in Fig. 607. When the axis of a tooth is not regular it should be loosened by moving backward and forward, and the movement should be in line with its strongest diameter, which lessens the danger of breaking the tooth.

In the upper jaw the inward movement is made after the outer, but with not so much force, as the structure on the inner side is more dense.

Rotation of a tooth in extracting is seldom practised, as the single-rooted teeth are usually flattened, and teeth that have more than one root cannot be rotated. Of the single-rooted teeth, the upper central incisors alone have roots nearly conical in shape which permit rotation as well as the out-and-in motion. A rotary motion is usually of advantage in extracting the roots of the upper first bicuspid when not double, and of the upper molars after the crowns are broken away so that the roots are disunited. These roots are usually round, conical, and somewhat curved in shape.

If possible, the tooth should be kept in view during the operation so that the results of the movements may be seen. A beginner may let the forceps slip and extract the wrong tooth when he is not observing each movement, but an experienced operator can depend on his sense of touch to a very great extent. The amount of pressure a tooth will stand while loosening it by an "out-and-in motion" depends on the size, condition, and density of the bony tissue surrounding it and the accurate fitting of the forceps to the tooth. Experience is the only reliable guide in this matter. When a tooth resists ordinary effort, if the operator is not quite sure of the cause of the resistance of the tooth, it is better to desist temporarily and allow the patient to rest, in order to investigate the condition of the tooth and its surroundings. Fig. 619 will give some idea of the causes of the resistance offered by apparently normal crowns.

After the forceps are applied and the tooth slightly moved, if the operator has a cultivated sense of touch he will feel that the tooth is yielding in one particular direction; as a general rule the tooth should be carried in that way.

The force applied to extract teeth safely and judiciously should be made with arm and wrist motion; if the whole body is used the sense of touch is blunted and accidents are liable to occur.

Extracting Deciduous Teeth.—In extracting the deciduous teeth the principles involved are nearly the same as for the permanent. A care, however, must be taken that is not necessary with the permanent

teeth, *i. e.*, to avoid injuring the developing permanent teeth that are situated immediately beneath them.

Fig. 634 shows all the deciduous and the developing permanent teeth except the third molars. It gives a true idea of their relative positions. Special attention is drawn to the position of the crowns of the bicuspids as related to the deciduous molars. This is also well

FIG. 634



Skull of a child, about six years of age, showing all the deciduous teeth in position and nearly all the developing teeth.

shown in radiogram Fig. 648. It will be seen that they are situated between the roots of the latter teeth, and by using undue force in adjusting the forceps these crowns could easily be misplaced, extracted, or injured.

If the deciduous teeth are extracted at the proper time they can usually be removed by the thumb and fingers as described. If not, one of the forceps shown in Figs. 576 and 577 should be used.

EXTRACTION OF INDIVIDUAL PERMANENT TEETH

The anatomy of the individual teeth and the majority of their often-repeated variations, as well as the general principles governing the extracting operation being understood, the extraction of each tooth will now be studied, those of the upper jaw being first considered.

The Upper Teeth.—*The Central Incisor.*—This tooth has a strong, round conical root. The forceps are carried into position by placing

the inner beak at the palatal surface of the neck of the tooth; the outer one is then placed in position and the instrument forced upward with a slight rotary motion between the gum and the tooth until it comes in contact with the alveolar process. As the root is round and conical, it is loosened by rotation and the out-and-in motion and then removed by drawing it directly from its socket. It is, as a rule, easily extracted.

The Lateral Incisor.—This tooth is much smaller than the central. The root is flattened and somewhat curved, the apex being often bent in the direction of the canine teeth. After applying the forceps as directed for the central incisor, the motion should be outward and inward. As the tooth has a delicate root, the force used must be light. When loosening and removing it, care must be exercised, as its root is not straight. The tooth is carried in the direction of the least resistance, which is usually toward the canine tooth.

FIG. 635



Canine, lateral, and central incisor extracted from maxillary sinus that were causing neuralgia.

The Canine.—This tooth is usually more firmly set in the jaw than any other, and it often requires considerable force to break up its attachments. The root is long and slightly flattened. After applying the forceps its attachments are broken up by the out-and-in motion. After loosening it is usually easily removed from its socket. As this tooth is erupted after the adjoining teeth are in position, it is often malposed. If the deciduous canine has been lost before its proper time, and the first bicuspid has pushed forward, there is no room for the canine to take its true position. This irregularity varies to a great extent. The canine may also be out of position from unknown causes. A marked specimen is seen in Fig. 628, where both canines are impacted. They were entirely covered by a bony lamina. (See also Fig. 644.)

Sometimes the roots of these teeth project into the maxillary sinus, or even into the nasal chamber, while the crowns are impacted between the palatal plate and the plate forming the floor of the nose. Fig. 635 represents a canine, lateral and central incisor, which were extracted from the sinus, the roots being embedded in its inner wall. Teeth thus impacted are often a source of trouble in various ways, and when discovered should be removed. When the tooth is so covered by bone that the forceps cannot be applied the bone must be cut away sufficiently to allow the forceps to grasp it. A very good instrument for removing the bone in the upper jaw is the elevator shown in Fig. 588; after the point has been sharpened it may be used as a chisel or gouge.

The Bicuspids.—The *first bicuspid* usually has a bifurcated root, and the only motion that can be used safely for loosening is the out-and-in, as these roots are sometimes considerably divergent. The removal after loosening is not always easily accomplished, a little outward

pressure being frequently necessary. If the force required is used too suddenly the inner root is liable to break.

The *second bicuspid* usually has a single flattened root, though occasionally it is bifurcated. The motion used to loosen this tooth is the outward and inward, using the same precaution as with the first bicuspid on account of the possibility of a double root.

FIG. 636



Showing position for extracting upper teeth of left side.

The First and Second Molars.—These teeth are nearly similar, having three roots, two buccal and one palatal, which vary so much in degrees of separation that no set rule can be given for their extraction. The roots of the first are usually more divergent than those of the second. Only the out-and-in motion can be used, rotation being out of the question in loosening them, as the roots often diverge to a great extent.

(See Fig. 627, *p.*) After the tooth has been loosened there is at times a difficulty in removing it, on account of the distance around the three roots; owing to their divergence this distance is greater than the size of the anatomical neck of the tooth corresponding to the opening of the socket. The only general rule that can be given is to carry it in the direction of the least resistance. Each tooth has more or less of an individual character, and therefore the operator must be governed by circumstances. The main precaution to be observed is not to be in too great haste, as there is danger of breaking one of the roots or removing a large piece of the outer plate of the alveolar process. (See Accidents, p. 606.)

Fig. 637



Showing position for extracting upper teeth of right side.

The Third Molar.—This tooth so varies as to the shape and number of its roots that it is seldom spoken of as an abnormal tooth, no matter in what form or position it may be found; the greater number have roots curved backward and outward. Their position in the jaw also varies considerably. The forceps shown in Fig. 576 is the instrument to use in extracting. After the forceps have been firmly placed the principal motion is the out-and-in, though more out than in. If there is much resistance the hand should be carried outward and upward, or in the direction of the least resistance. This tooth is sometimes erupted at the side of the alveolar process (Fig. 638), with its occlusal surface pointing toward the cheek. (See Figs. 645 and 646, radiograms made from the specimen shown in Fig. 638.) It is not well to have the mouth

opened too far, as it brings the coronoid process of the lower jaw in the way.

In stating the general rules of extracting, caution was given not to make the movements faster than could be seen; this applies very particularly to the third molar. It is so near the ascending ramus in the lower jaw that it is possible, especially when the roots are curved and spread out, to fracture this angle, or in the upper jaw the tuberosity may be broken away, thus opening into the maxillary sinus. The gum tissue often adheres to the posterior portion of this tooth; when this happens it is best to desist from attempts at extraction and sever the tissue from it with a curved lancet or scissors before removing the tooth with the forceps, or, as before advised, dissect the gum away before applying the forceps.

FIG. 638



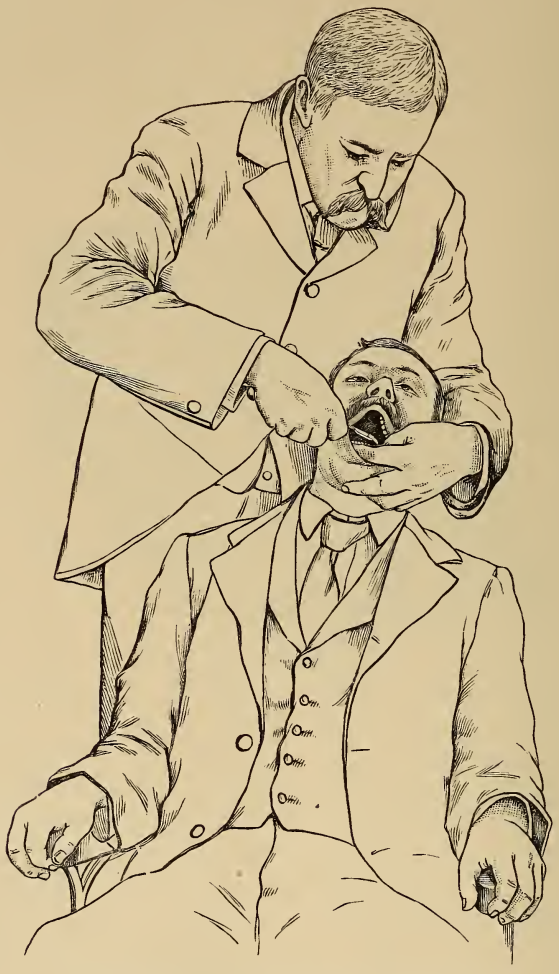
An impacted upper third molar. A similar condition found on the opposite side of the skull.

The Lower Teeth.—As a rule, the teeth of the lower jaw are more difficult to extract than are those of the upper jaw, the lips and cheeks being in the way. The tongue is also troublesome, covering the tooth, and when the inner beak of the forceps is placed in position special care must be used to prevent part of the tongue or floor of the mouth from being caught in the instrument.

The Oral or Anterior Teeth.—(For position see Fig. 639.)—These six teeth have small single, straight, compressed roots. Their extraction is only necessary when they become loosened by accident or from disease, or when it is necessary to clear the mouth for inserting artificial teeth. The operator should stand a little back and to the right side of the chair, being somewhat elevated above the usual position. Pass the first finger of the left hand between the lips and the alveolar border, and place the remaining fingers beneath the chin with the thumb on the inside of the teeth. For the incisors use the lower root forceps

shown in Fig. 587 or the universal forceps shown in Fig. 577. The canines are larger and more firmly set; delicate root forceps, therefore, are not usually suitable; the instrument shown in Fig. 577 or, better, the bicuspid forceps (Fig. 585) are much to be preferred. An out-and-in motion is proper for loosening all these teeth.

FIG. 639



Showing position for extracting lower anterior teeth.

The Bicuspids.—The lower bicuspids have compressed roots seldom bifurcated, and are generally extracted by the out-and-in motion. The special forceps for these teeth should be made so that they grasp a considerable portion of the surface of the tooth. These teeth are often difficult to extract without breaking when all the teeth are in position, the roots being long and narrow and often situated in an awkward

position. As shown in Fig. 606, the position of the roots of the second bicuspid is a little to the inner side of the anterior root of the first molar. The tooth illustrated in this particular case would be very difficult to extract without breaking.

The First Molar.—(For position see Fig. 640 for the left side, 641 for the right side.)

The first molar, if in a mouth where all the teeth are in position, is generally the most difficult of all the teeth to extract. The roots are usually long and diverging. It is lower in the arch than the other teeth, and is in fact similar to an inverted keystone; consequently, when

FIG. 640



Showing position for extracting lower teeth on the left side.

extracted it is drawn through the arch. When the teeth are close together the second bicuspid and second molar yield a little, but great care must be taken that one or both of these teeth are not extracted with the first molar. In placing the forceps on the lower molars the points of the beaks of the special molar forceps (Fig. 573 or 586) are placed in between the roots on each side of the tooth. Care should be exercised to avoid including a portion of the tongue or soft tissues of the floor of the mouth in the forceps. If the forceps are not well placed the wrong tooth may be extracted, as it is possible for them to slip in between two teeth.

In loosening these teeth the out-and-in motion is used, and as they are wedged in it is often necessary to continue this motion while extracting them from their sockets. At times it is advisable to move the tooth outwardly after it has been slightly lifted from its socket. Occasionally the roots diverge so far that either the crown has to be broken from the roots at their bifurcation or the tooth divided in the line of bifurcation with splitting forceps; each root being then extracted separately.

The Second Molar.—The roots of this tooth are not as diverging as those of the first molar, as may be seen by examining Fig. 602, nor is the tooth wedged in as tightly as in the case of the first molar.

The out-and-in motion is required for these teeth, using the same precautions that are necessary in the extraction of the first molar.

FIG. 641



Showing position for extracting lower teeth of the right side.

The Third Molar.—In this tooth the roots may vary so much in number and shape that it can hardly be said to be a typical third molar. Fig. 602 shows what might be called a typical third molar, but these are only found in well-developed jaws, where the teeth are not so large as to cause crowding, or where there has been no inflammatory condition causing excessive deposit of lime salts within the cancellated tissue. They vary in character from the one shown in Fig. 602 to those shown in Figs. 613 to 624 inclusive. There are also third molars having three,

four, or five roots. In Fig. 627, *a* shows another form of the third molar; *b*, *c*, *d*, *e*, and *f* show where the third molar has united with the second molar; *g* and *h* illustrate three molars united; *i*, *j*, *k*, *l*, *m*, *n*, *o*, and *p* show variations of roots. The positions these teeth occupy may vary in all degrees from that shown in Fig. 602 to those shown in Figs. 613 to 624 inclusive.

Where the third molar is in the position shown in Fig. 602, and there are no other complications, its extraction is easy. The tooth is removed by placing either the special lower molar forceps shown in Fig. 586 or the forceps shown in Figs. 576 and 577 in position, and using the out-and-in motion with a slight raising of handles. If Fig. 576 be used the beaks should be turned downward and the handles carried upward. But when it is of irregular form and position, as shown in the various illustrations, the difficulty increases with the degree of variance from that of the typical tooth shown in Fig. 602. These cases should be closely studied. If portions of the teeth are in view, as shown in Figs. 619 and 620, they will assist to some extent in the diagnosis of the position of the roots. In this particular case the bone as well as the roots being much hypertrophied, it would be impossible to extract the roots without fracturing the process to a greater or less extent. It will be noticed, on examining the section Fig. 619, that to have fractured the inner portion of the jaw, the inferior dental nerve and vessels and also the mylohyoid nerve and vessels would be endangered. If in attempting to extract this tooth it should not yield to a pressure which if increased would break the bone, it is better to desist and cut away the bone with a bur (shown in Fig. 651) in the surgical engine, as was done in the case of the specimen from which the illustration was made.

The Extraction of Malformed and Abnormally Placed Teeth.—The term "impacted teeth" is generally used to designate permanent teeth which are abnormally placed or have failed wholly or partially to erupt. It is also sometimes employed to indicate the retarded eruption of deciduous teeth.

Order of Frequency of Abnormally Placed Teeth.—The experience of the writer has been that the order of frequency of impacted teeth is as follows: First, the lower third molar; second, the upper canines; third, the upper third molar; fourth, the upper central incisor; fifth, the lower second premolar; sixth, the upper second premolar; seventh, the lower canine.

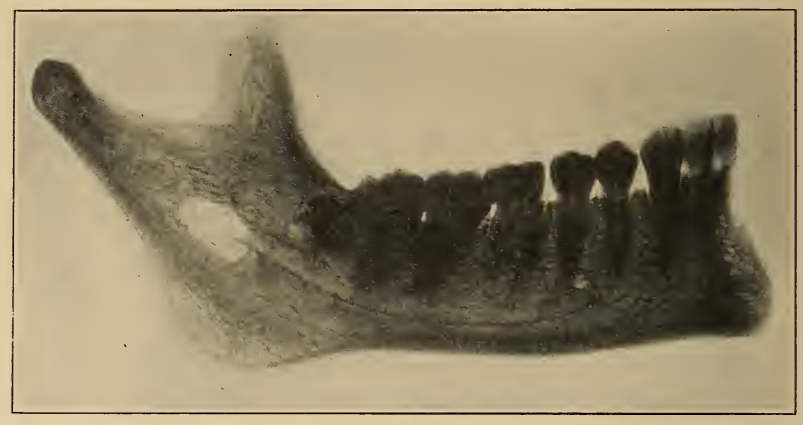
Diagnosis.—Many malformed and abnormally placed teeth are entirely hidden from view, and those in which the crowns are partially seen give only a suggestion of the cusps while the shapes and positions of their roots are difficult to diagnosticate. In order that the extraction may be intelligently made, a forty-five degree angle hatchet-shaped excavator is one of the most useful instruments to use as a probe to determine the position of the crowns and roots, especially when used by one experienced

in the handling of such an instrument and who is thoroughly conversant with the normal and pathological anatomy of these parts. No one without this knowledge is properly equipped to diagnosticate such malposed teeth, much less to extract them.

The improvement of radiography, especially in the technique of its dental application, has been so rapid and its results so accurate, that the use of the *x*-ray in the diagnosis of impacted teeth has become indispensable, especially in cases where none of the tooth is exposed to view.

Figs. 614 to 624 inclusive are made from photographs showing some of the positions in which lower impacted third molars are found. These illustrations were made from cleaned specimens. Fig. 638 shows the crown of an impacted upper third molar where a portion of the bone has been removed.

FIG. 642



Radiogram of mandible, showing rudimentary fourth molar

Fig. 622 is made from a radiogram of both halves of the bone of the same boiled or cleaned mandible. It shows two deformed and misplaced lower third molars. In the upper picture the tooth is nearly in a horizontal position with its occluding surface well "locked" under the posterior surface of the second molar. It will be noted that the roots are curved upward and backward above the inferior dental canal or tube. The roots of the second and third molars are enlarged by the irritation resulting in the overactivity of the cementoblasts, the crown of the second molar is tipped backward, probably from the pressure of the anterior cusp of the third molar. In the lower picture the third molar seems to be in line to take its proper place but its anterior cusps are caught under the crowns of the second molar and the solid bone posterior to it prevents it from taking its normal position; the roots of this third molar extend below the line, and to the lingual side, of the

inferior dental canal or tube. The roots of the three molars are enlarged by an extra deposit of cementum.

Fig. 642 is made from a radiogram of a cleaned specimen, which shows an impacted rudimentary lower fourth molar The roots of the second and third molars are thickened, the surrounding tissue being more dense than normal. These conditions are difficult to diagnosticate in the living subject and are best revealed by a good radiographic plate

Fig. 643 is made from a radiogram of a cleaned specimen which shows a lower tooth in the ramus of the jaw.

Fig. 644 is made from a radiogram of a cleaned skull which shows an impacted upper right canine tooth lying across the roots of the central and lateral incisors, also in close juxtaposition to the roots of the first and second premolars. The end of the canine root is in the wall of the maxillary sinus.

Figs. 645 and 646 are two pictures made from radiograms of a cleaned skull (see Fig. 638). They show two impacted upper third molars, one on each side of the jaw. Fig. 645 shows them apparently in close relation, while in Fig. 646 they are wide apart. The cause of this apparent difference of position is that in the first picture the teeth on the opposite sides of the jaw are nearly in a line with the anode or target of the *x*-ray tube, while in the second picture the tube is placed a little farther back, causing the impacted tooth and the teeth nearest that side to be thrown forward, apparently placing the impacted tooth in the maxillary sinus. It requires some practice to read correctly pictures of this kind and avoid an error of diagnosis due to an optical illusion such as that shown in the case here illustrated, the teeth that show most distinctly are those that are nearest the plate when the radiogram was taken. When there is an impacted tooth or teeth in each side of the jaw it is necessary to take two pictures, one radiogram placing the plate on the right side and another one with the plate on the left side. In film pictures the confusion of the sides is avoided, but it is almost impossible to obtain a radiogram on a film of so highly placed impacted teeth as in this case.

Fig. 647 is made from a radiogram of a patient, showing a rather common case of impacted lower third molar, also an upper right molar that has not erupted into its normal position. When the plate of this picture is carefully examined there is shown to be a condition in the opposite side similar to those shown in Figs. 645 and 646, which made it necessary to have another plate made to give a clearer view of the other side of the jaw.

Fig. 648 is made from a radiogram of a patient about the age of ten. This picture shows the lack of development of the lower left second and third molars; it also shows that the upper second molar is in a false position with no germ of the third molar showing. The deciduous premolars are shown immediately over the permanent premolars, bicuspids, which demonstrate that in extracting deciduous teeth the

forceps must not be forced down below the crowns. The same conditions are shown in Fig. 634.

FIG. 643



Showing tooth malposed in ramus of the mandible.

FIG. 644



Radiogram showing impacted canine.

Fig. 645



Radiogram showing impacted third molars.

Fig. 646



Same case as Fig. 645, taken from different angles.

Fig. 649 is made from a radiogram film, it shows an impacted lower third molar. This tooth is in such a position that its occluding surface can be cut away with a disk.

Fig. 650 is made from a radiogram film; it shows a lower third molar impacted below the second molar, apparently advancing between the second and first molar. The patient was suffering not only in the immediate region, but also in the surrounding parts of the temporo-mandibular articulation. Extraction of the first molar was all that was necessary to produce almost instant relief, and the third molar soon began to advance to the position of the first.

Fig. 647



Showing impacted lower third molar and malposed upper molar.

Abnormally placed teeth usually give considerable trouble, if not in early life, they do later on, the seriousness of this disturbance depending largely upon the location and malformation of the misplaced tooth and upon the general conditions of the patient. If left impacted these teeth are liable to prevent the proper nourishment of other teeth, as shown in Figs. 615 and 628. They are also liable to press upon the branches of the fifth pair of nerves, producing severe neuralgia not only in the locality of the lesion, but in remote parts. They are also liable

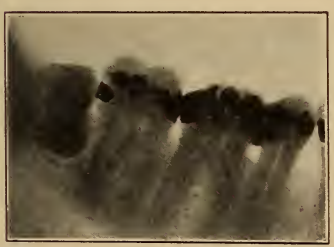
to bring about inflammatory conditions of this region, producing cellulitis in the tissues of the mouth, neck, and throat. They interfere with the temporomandibular articulation, cause disturbances in the nasal

FIG. 648



Same case as in Fig. 647, taken from a different angle.

FIG. 649



Impacted lower third molar.

FIG. 650



Impacted third molar below the second molar.

cavity and the associated pneumatic sinuses and cells, and even interfere with hearing. They may even contribute to the production of malignant growth of the bone and surrounding tissue.

Many cases could be cited where serious pathological conditions have been produced, such as chorea; also various degrees of mental disturbances, even insanity, which have been relieved by the treatment of removal of malposed teeth. The conditions under which these teeth are formed vary so much that the same rules for extracting under ordinary circumstances cannot be applied to them except in a general way. After the diagnosis of the character and position of the tooth has been made, then the operation is to be planned out. As a rule, the offending tooth should be removed or liberated without the sacrifice of any other teeth, but there are cases in which other teeth should be extracted. There are several points to be considered: The character of the tooth and its position, the character of the adjoining teeth, age, and general health of the patient.

When the impacted tooth can be brought into useful position by the removal of causes impeding its eruption, the necessary steps should be taken for its liberation, occasionally it will be found advisable to extract teeth other than the impacted one, thus allowing the retarded teeth to erupt into the place of the extracted one. For example, there are cases where a lower or upper third molar will erupt into the place of an extracted second molar. Then again in cases similar to those shown in Fig. 615 and 638 one should not extract the impacted tooth without first extracting the second molar as the danger to the surrounding tissues and bone necessarily incident to the removal of the impacted tooth is too great.

The surgeon must, of course, save teeth where he can, but it is more important to conserve surrounding tissues and avoid injury to the jaws. In other words where grave pathological sequelæ of impacted teeth are present or imminent, it is more important that these consequences should be cured or avoided than that a tooth or teeth otherwise useful should be retained.

The following descriptions will cover the general procedure of extracting ordinary forms of impacted lower third molars. (See Figs. 621, 622, and 650.) If the teeth are well up and the crowns are exposed so that the occluding surface can be cut away it should be done with a carborundum disk, which will "unlock" the third molar from the second, then if the bone overlying the roots is not too dense the tooth can be lifted from its socket by the use of an elevator (Fig. 588); if, however, the bone is dense, it must be cut away until the remainder will yield to the pressure from the elevator. In teeth like those shown in Figs. 615 and the upper picture of 612 it would be impossible to use the disk to unlock the tooth without injuring the surrounding tissues. In Fig. 615 it would be advisable to extract the second molar, as it is badly decayed and devitalized, although it is more than likely that in this particular case the third molar would not ascend to a serviceable position. In lower picture (Fig. 622) the writer would recommend the extraction of

the second molar, as there is every probability that the third molar would then become a useful tooth. In those cases where the use of a disk will not unlock the third molar and it is not desirable to extract the second, the process of removing the impacted third molar becomes a more serious operation, and, as a rule, should be done in a hospital, where all conveniences and assistances are at hand, for the removal of some impacted teeth is more difficult and serious than even some of the major operations of general surgery. The patient should be etherized, a mouth gag fixed in position, and a portion of the soft tissue removed with a small knife; then using a revolving spiral osteotome (Fig. 651), operated by the surgical engine, the bone covering the greater portion of the tooth can be cut away until the elevator will lift the tooth out of its bed. It is sometimes better to cut through the crown or neck of the tooth until it is so weakened that when the elevator is forced under the tooth, it will break at this point. This would allow each portion to be removed. When it is impossible to force the elevator (shown in Fig. 629) between the bone and the tooth, a space can be made by pushing a revolving osteotome between the tooth and the bone, cutting a portion of each, which will make sufficient opening for the use of the elevator.

Fig. 651



Two forms of Cryer's spiral osteotome.

The writer now seldom uses the forceps to remove a tooth after loosening it with the elevator. In using the elevator on the left side, it is operated with the right hand, the surgeon standing on the left side of the patient. The left forefinger is placed in the mouth, by the lingual side of the tooth, and the thumb is placed on the buccal side of the first and second molars. This gives steadiness to the jaw and lessens the risk of slipping. As the tooth is raised from its socket, the forefinger is

Fig. 652



A B C

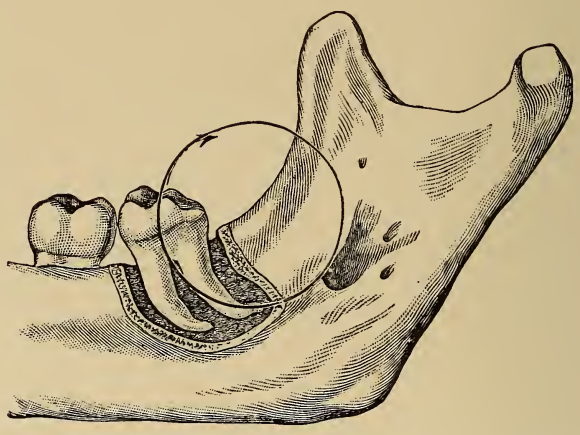
Showing three views of a lower three-rooted molar tooth.

placed so as to bring the tooth out of the mouth. If the tooth to be removed is on the right side, the elevator should be used with the left hand if possible (the surgeon standing on the right side). If the operator must use the elevator with his right hand, he should, however, manage to guard and steady the parts with his left hand.

Fig. 652 is made from three photographs of a lower three-rooted

molar tooth after extraction. *A* shows the outer or buccal side of its roots, in about the same position as when in the jaw. The posterior cusps were broken away in a former endeavor to extract it. The greater portion of the crown was cut away with the surgical engine. On the side of the tooth there is a groove extending backward, downward, and inward, cut by the osteotome. It was along this groove that the elevator was forced under the tooth, causing the slight remaining portion of the crown to fracture. In *B* the tooth is turned slightly outward, in order to show three roots and the line of fracture which liberated the tooth. In *C* the tooth is turned upon its buccal surface, showing the two anterior cusps which were locked under the distal surface of the second molar.

FIG. 653



Showing the direction in which the lower third molar is to be extracted.

In Fig. 613 the third molar is in such position as to be easily extracted, though if proper care were not used the extraction might have serious consequences. It will be noticed that the points of the roots are just through the inner U-shaped cortical portion of the lower jaw below the mylohyoid ridge and project into the submaxillary region. Now, should this tooth or the roots be pushed downward in attempted extracting, as is sometimes taught, it might be forced into the submaxillary region and consequently be lost for a time, with the possibility of having to perform a subsequent surgical operation to cut it out from the neck.

An impacted third molar often causes great distress by initiating an inflammation which extends to the region surrounding the angle of the jaw, and often including the temporomaxillary articulation and soft parts within the mouth. Under these conditions the jaws can only be partly opened, deglutition is impaired, and solid food cannot be taken. If any part of the tooth can be seen, the difficulty is not so great. Relief must be given, and, as a general rule, the offending tooth should be extracted. Circumstances may arise in which the removal of the second

molar may become an unavoidable preliminary to the removal of the third molar. As the mouth can only be opened slightly, it is impossible to use the large special molar forceps. An elevator is sometimes recommended in these cases, but it may prove to be a dangerous instrument to use under such conditions, for when the tooth is lifted out of its position in the mouth, it might slip back into the larynx. It is well in some cases to loosen a tooth with an elevator and then remove it with the forceps shown in Figs. 576 or 577, as they are small, and are so shaped that the beaks may be carried back to the tooth mainly along the vestibule of the mouth, the inner blade being placed between the teeth by passing the forceps back of the second molar. Often it is impossible to see completely what is being done; therefore it is not well for a beginner to undertake this kind of extracting. After the forceps are in position the tooth should be worked in any direction in which it will yield; this is generally outward, upward, and backward, in the manner of unfastening a hook (Fig. 653). When the lower third molar is impacted near the gonion or external angle of the jaw, it may be necessary to open it from the outside through the soft tissues. When such is the case the surgical engine should be used for cutting the bone.

TREATMENT AFTER EXTRACTION

The operator should recognize immediately any accident that may have happened during the operation of extraction, and treat it as the circumstances indicate; but if nothing unusual occurs, then the patient may be allowed a few moments' rest, after which the mouth should be carefully examined. If there be any loose portions of the process or pieces of gum hanging to the parts operated upon, they should be removed by any convenient means, such as small forceps, a curved pair of scissors, or a curved lancet (Figs. 590 and 592).

When several teeth have been extracted, leaving ragged edges of the outer walls of the alveolar process, these should be removed with the excising forceps, or, better still, by the use of either forceps Fig. 576 or 577, according to circumstances, as the beaks can be carried between the gum and the process better than can the blades of the excising forceps.

An antiseptic mouth wash, consisting of a tablespoonful of phénol-sodique to a glass of water, should be used several times daily for the next few days. Any other suitable antiseptic mouth wash which may be more agreeable to the patient may be used instead, although the phénol-sodique is highly efficacious.

Occasionally, in a few days after extraction, pain will be noticed in and about the alveolus, especially when the tooth has been the seat of pericemental inflammation. Relief in such a case is usually given by removing any clot that may have formed, and breaking down the

degenerated tissues which should have adhered to the root. A pledget of cotton saturated with the full-strength solution of phénol-sodique or campho-phenique should then be inserted as a dressing.

ACCIDENTS

When accidents of any kind whatever occur, the operator should be calm and appear perfect master of the situation. He should be prepared to deal successfully with whatever conditions may arise.

FIG. 654

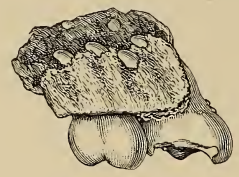


FIG. 655



FIG. 656



FIG. 657



FIG. 658



FIG. 659

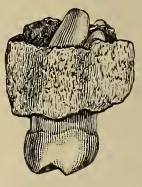


FIG. 660



FIG. 661

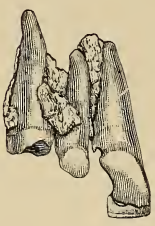


FIG. 662



One of the most common accidents is the breaking of a whole or portion of a tooth or root. If the operator has any doubt of his ability to remove the tooth entire, he should inform the patient that there is a possibility of its breaking, in which case not to be alarmed. If the tooth is removed without breakage, so much the better; even if it does break, it will not cause alarm to the patient. It is more desirable that all of a tooth should be removed, for if its surrounding membrane has been inflamed, or if a root having a portion of the pulp attached has been broken, either will be the source of obstinate pain.

It is better, however, under some circumstances to let certain roots remain if they are broken than to break away a large amount of process. Roots are sometimes so situated that they may be easily forced into the maxillary sinus (see Figs. 604 and 605), or into the submaxillary region (see Fig. 613), or upon the inferior dental nerve. If there exist reasons for believing that the root will not cause undue pain, and there be danger of breaking a large amount of process, it is preferable to let it remain, as in a short time the contraction of the soft parts and their expulsive efforts will force the root outward, and it may then be removed without danger. If roots are forced into the maxillary sinus they must be followed and removed.

When several teeth are to be extracted under an anesthetic, if the gum should adhere unduly to one of them, the operator should desist from its removal and proceed with the other extractions, after which the adherent gum should be severed with a curved lancet or a pair of curved scissors and the tooth then removed. If the gum be much torn and the bone exposed to a great extent, it should be held in place by a few interrupted sutures. If, however, proper care be taken in extracting, this should not occur.

In extracting crowded teeth, or those having frail alveolar surroundings, it is possible to remove a piece of the alveolar plate, especially in extracting the first and second molars, the broken piece extending backward, forward, or in both directions to the adjoining tooth (see Figs. 654 to 662). The tooth in front may even be partially lifted from its socket. As soon as the operator sees the impending accident he should either stop and see if his method of extraction could be improved, or, this point being negatively decided, hold the parts in position with the left hand as well as he can, and after the tooth is removed force the injured parts into position; they will usually stay, but if not, appropriate appliances should be used for retention.

In extracting the upper third molar, the tuberosity is sometimes broken away, opening into the maxillary sinus (see Figs. 654, 655, 656, 659, and 662, showing where teeth have been carried away with the tuberosity). If it is a simple fracture the parts should be forced into place and they will in a short time reunite. But if the parts are torn loose it will be of little use to try to replace them; the best course is to trim away the ragged edges, using the curved scissors for that purpose.

After such a fracture it is possible that hemorrhage may occur from rupture of the superior dental artery. This is sometimes difficult to control. One of the best remedies, however, is to pack the parts tightly with medicated gauze. This application must be left in for a few days and then be carefully removed. It is sometimes well to take out only part of the gauze at a time, the loosened portions being cut off with a pair of curved scissors. Hemorrhage after extraction usually ceases in a short time, and then there is no occasion for treatment; when,

however, the adjoining parts are much inflamed, or if the patient is in an anemic condition, or the case is one of hemorrhagic diathesis, special treatment will be necessary.

Hemorrhage of extraction may be divided into two classes, arterial and capillary. When arterial, it is usually located in the socket of the tooth, and may usually be stopped without much difficulty by taking a twist of absorbent cotton, shaping it into a thin tapering roll, and

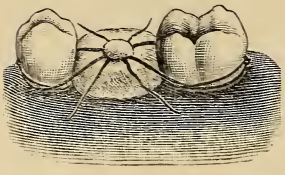
Fig. 663



Barton's head bandage.

thoroughly packing the socket. Before inserting the cotton tampon, it should be rolled in tannic acid until the fibers will hold no more, then the cotton is to be packed tightly into the alveolus with a dental plugger. In packing the cotton it is well to begin at one end and crimp it upon itself until the socket is entirely filled. The plug in a few cases may require retention in position by compression. This is accomplished by holding a few folds of muslin or similar material over the plug, closing the mouth and binding the jaws together with a few turns of a Barton's bandage (Fig. 663). The 25 per cent. ethereal solution of hydrogen dioxid in small quantity on cotton packed into a bleeding socket is a most efficient styptic, and will effectually control severe hemorrhage after extraction. Care must be exercised not to use the solution in excess, as it may cause injury to adjacent parts.

Fig. 664



Showing compress and ligatures.

When hemorrhage occurs from the surrounding tissue, as in patients in an anemic condition or in cases of hemorrhagic diathesis, the case usually falls into the hands of a general practitioner for systemic treat-

ment, but the local treatment usually employed by physicians in these cases is often unsatisfactory, many using Monsel's solution of persulfate of iron, which, although it may be a good styptic for use in other parts of the body, should not be used in the mouth. The local treatment in such cases, whether soon after extracting or not, is first to remove all clots from the wound and find the exact place or places from which the blood is exuding. A suitable styptic and compression are the principal means used for stopping it, the latter perhaps being the most important. Tannic acid applied on cotton, lint, or similar substances is an excellent styptic for this use. Compression can be applied as the ingenuity of the operator may direct. When a hemorrhage occurs from a socket between sound teeth, it can be readily controlled by two ligatures, making one fast to each tooth, then placing in position and tying the four ends together over the compress, as shown in Fig. 664. In a few rare cases an impression of the parts should be taken in wax or modelling compound in order that a vulcanite or metallic plate can be made to hold the styptic compress in position. After the compress is in position warmed modelling compound can be placed over it and the jaws brought together and retained in place by a head bandage. A plug of hardening plaster of Paris may be made and forced into the bleeding socket in obstinate cases, or *in extremis* the extracted tooth might be soaked well in phénol-sodique and reinserted. A very efficient local hemostatic is a 1 to 1000 solution of adrenalin chlorid. A piece of iodoform gauze moderately soaked in this solution and packed in the tooth socket will often control severe hemorrhage. This drug acts by causing constriction of the bloodvessels. It is the most powerful vasoconstrictor known, although its effects do not last long.

The systemic treatment is often important; if the patient is seen to be anemic or known to be of the hemorrhagic diathesis, the treatment should be begun before extracting. This is done by thoroughly building up the system by a course of hygienic and tonic treatment. The cause of bleeding in cases where the hemorrhagic diathesis exists is but imperfectly understood; the blood may be so defibrinated that it has lost the power of coagulation and so will not form a clot, or the muscular coats of the vessels have lost their tonicity, either through general debility or the lack of energy in the vasomotor nervous system, which prevents their contracting so as to close the lumen. Certainly the walls of the capillaries permit free transudation of the blood. In good health the proper coagulation and the contraction of the bloodvessels will stop the hemorrhage even when an artery of considerable size is lacerated, especially if the flow be held in abeyance by artificial means for a short time. It is when the blood will not coagulate and the vessels fail to contract that a thorough systemic treatment must be given. This lack of normal function on the part of the blood and

vessels may arise from various diseases, and in order to treat judiciously a patient exhibiting the hemorrhagic diathesis, a thorough examination must be made and such treatment given as the diagnosis indicates. Among the most common causes of hemorrhage are anemia, syphilis, purpura, tuberculosis, and a generally impaired vitality, rarely an overacting heart; the passive hyperemia attendant upon a weak heart is a potent factor requiring a course of preliminary treatment.

Specific and special diseases must of course receive the treatment peculiar to these conditions. On general principles the following tonics are advisable: Quassia, cinchona and its alkaloids, iron in its various forms, sulfuric and hydrochloric acids, arsenic, phosphorus, nux vomica and its alkaloid strychnin. Of general or constitutional hemostatic remedies, the best are certain salts of calcium, such as the chlorid and the lactate, and of magnesium such as the carbonate. They act by increasing the coagulability of the blood. It must be remembered, however, that an excess of calcium salts tends to reduce the coagulability of the blood, so that prolonged use of these drugs may do more harm than good. A combination of these seems to be more effectual than calcium chlorid alone. Thirty grains of calcium chlorid or lactate with thirty grains of magnesium carbonate may be given as an initial dose followed on succeeding days by fifteen grains of each drug or five-grain tablets of extract of thymus gland may be given up to twenty a day to supply the nucleo-albumin necessary for coagulation of the blood. Very frequently the digestive organs require special medication, when such remedies as pepsin, pancreatin, hydrochloric acid, and bismuth subnitrate are indicated.

The following prescriptions have proved to be very excellent in their special province.

As general tonics:

℞—Sodii arsenit. gr. j
Ferri sulphat. exsiccat.,
Sodii bicarb. āā ʒj
Ft. pilulæ No. xx.
Sig.—One after each meal.

℞—Strychninæ sulph. gr. j
Acid. hydrochlor. dil. ʒij
Infus. gentian. comp. q. s. ad ℥iij
Sig.—Teaspoonful in water after each meal.

In cases of undue hemorrhage after extracting, it is well to administer a hemostatic, while at the same time styptics and pressure are being applied locally.

EXTRACTION UNDER THE INFLUENCE OF GENERAL ANESTHETICS

While it is undoubtedly true that the extraction of teeth under the influence of a general anesthetic is in accordance with the general spirit

of the age which seeks to spare all suffering or cause the infliction of but slight pain, yet many evils attend such general and too often indiscriminate use. "A patient under the effect of so powerful a drug that consciousness is destroyed is nearer death than an ordinary human being, since the primary depressive influence upon the high nervous centres may speedily pass to the lower vital centres in the medulla oblongata."[1]

The indiscriminate use of general anesthetics, besides their possible danger to life and health, has an accompanying evil in the demand for the extraction of teeth which are salvable and useful, but which a patient insists upon having removed in order to avoid the discomfort attendant upon their treatment and filling. No one questions or denies the enormous benefit of general anesthetics in dentistry, particularly when painful operations are to be performed upon nervous women and children; but if the patient be willing to suffer a little pain it is generally better to extract without a general anesthetic, as in that case the patient can assist the operator by keeping the head in a desired position with the mouth and lips well open, and in various other ways, while under the influence of an anesthetic the muscles supporting the head, jaws, and cheeks are so relaxed that it is difficult to keep the mouth and lips well open.

If the operation is to extract a difficult tooth, the operator is limited to the time when the patient is under the influence of an anesthetic, and in the case of nitrous oxid the time is very short; but without an anesthetic there is not this limitation as to time, and the extraction may be done with that care and deliberation essential to a proper operation. It is an important rule in any branch of surgery that the time required to do an operation must be sufficient to do it properly and without unnecessary injury to the adjoining tissues.

Examination of a Patient before the Administration of a General Anesthetic.—The physical examination should be made in such a way that it will not cause alarm to the patient. The result of this examination governs the selection of the anesthetic, and to some extent shows how far the patient should be carried under its influence. It has been said that a greater amount of care should be used if the patient has or is suspected of having organic or functional disease of either the heart or the lungs. This is quite true; but at the same time the greatest amount of care should be observed in all cases.

The question often arises whether anesthetics should be used at all if the patient has either organic or functional disorder of the heart. That depends to a large degree on other conditions of the patient. If the shock of extraction will be less under ether or nitrous oxid, then by all means the anesthetic should be given and the patient carried well

[1] H. A. Hare, Park's Text-book of Surgery, vol. ii.

under its influence, so that there will be neither pain nor knowledge of the operation. Occasionally patients suffering from heart disorders can bear a certain amount of pain without shock; in such cases it is better, if the operation be a simple one, to extract while in the normal condition.

It is also true that an individual may show on examination evidences of considerable organic defect of the heart without running any more risk than a person who shows no such signs. For example, a loud systolic murmur may be heard at the apex of the heart, a sign of mitral regurgitation, and at the same time the patient will be in the best of health as far as functional activity of the heart is concerned. Therefore the presence of a cardiac murmur in itself is no contraindication to the use of an anesthetic, but if the patient shows signs of poor compensation, *i. e.*, marked dyspnea, cough, edema of the feet, or irregularity of cardiac action, extreme caution should be employed.

These remarks apply to anesthesia for the shortest dental operation whatever the anesthetic. In longer operations such as extraction of impacted teeth, when the anesthesia must be complete and kept up for some time, thorough examination of the lungs and kidneys should also be made. Pulmonary tuberculosis and chronic bronchitis are contraindications to ether anesthesia. In testing the function of the kidneys, the quantity of urine excreted in twenty-four hours as well as the presence of albumin or casts should be noted. Ether is a powerful irritant to the kidneys, albumin and casts appearing in the urine after its administration in a great number of cases in which they were previously absent. This action of ether must therefore be borne in mind in its administration.

Ether is a much safer anesthetic than chloroform. Statistics from various sources show the death rate from ether to be about 1 in 16,000, and from chloroform 1 in 4000, a proportion of 1 to 4.

Chloroform, therefore, should not be used except under very exceptional circumstances and never for the short operations here under consideration. Many writers recommend its use especially in children rather than ether, but there is no evidence to show that it is more suitable for them than for adults. It has been truly said by one of our leading teachers, "There is no use in a dental surgery for chloroform except to dissolve gutta-percha."

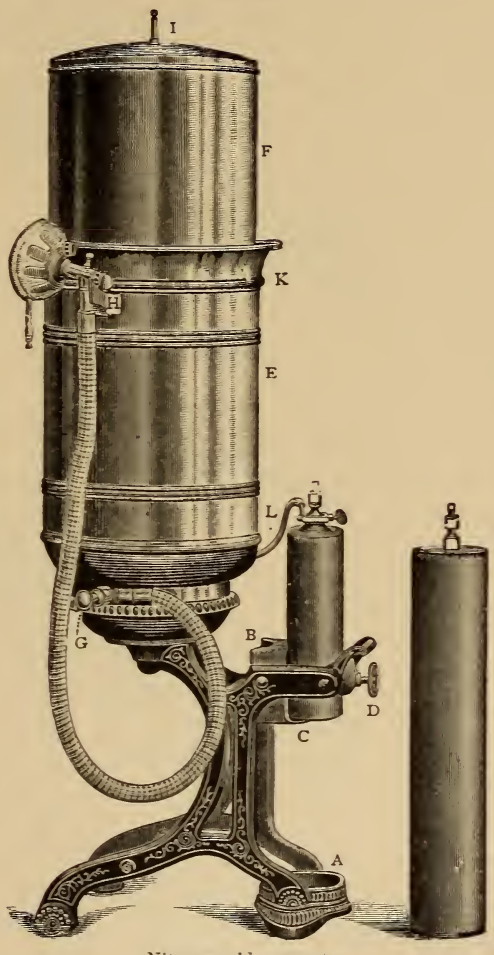
The disagreeable effects of anesthetics can to a great extent be avoided by proper preparation of the patient. In all long operations the patient should take a laxative in the evening, followed on the morning of operation by an enema of soap and water. The patient should eat no breakfast on the day of operation, which is therefore best performed in the morning.

Before the operation the patient should be asked to empty the bladder and bowels if possible, the clothing should be loosened about the neck,

and all removable artificial dentures should be taken from the mouth, and a mouth prop placed in position.

The ordinary dental chair is not well suited to operating under general anesthetics. In nitrous oxid anesthesia, the body assumes a position of hyperextension and the foot rest or other parts of the dental chair may be broken by the force of the muscular contraction. If a dental chair must be used, the foot-rest should be lowered out of reach of the patient's feet before giving the anesthetic, and a detached stool placed beneath the feet. For longer operations, the patient should be placed in a recumbent or semi-recumbent position.

FIG. 665



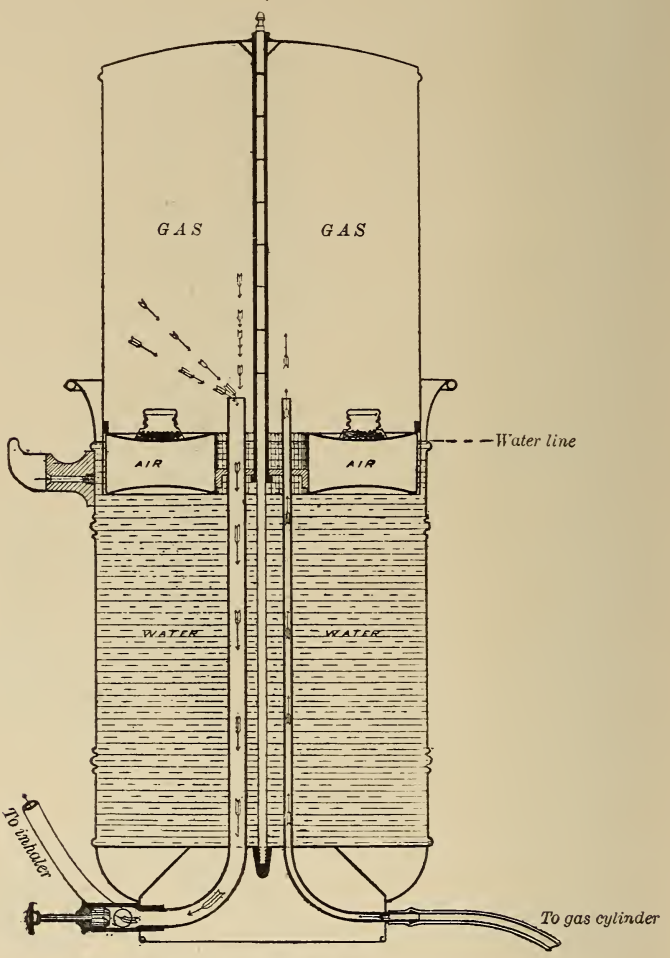
Nitrous oxid gasometer.

The use of ether for extracting has certain advantages. If for any reason the operation requires longer time for its performance than the influence of the nitrous oxid will last —say from one to two minutes—it is better to use ether. Ether can be given after the patient has become anesthetized by nitrous oxid and oxygen, and he may be kept under its influence for a considerable time; in this way the struggling stage of ether may be avoided. When the teeth are to be extracted at the patient's home or at any other place outside of an operating room, ether is more conveniently carried than nitrous oxid. If properly used and the patient has perfect confidence in the operator, ether can be so administered that one, two, or three teeth may be extracted during what is known as the first stage of ether anesthesia, before complete unconsciousness and long before the struggling stage commences.

The best way to accomplish this is to administer the ether in a cone made

by a napkin or towel, with the small end slightly opened so as to allow the patient to inhale a sufficient quantity of air; it also permits the patient to exhale freely and with a less suffocating effect. It is well to place in the cone a small soft sponge that has been well washed with hot water. After the cone is ready the patient should be instructed to breathe several long and full inhalations; this clears the lungs of much impure

FIG. 666

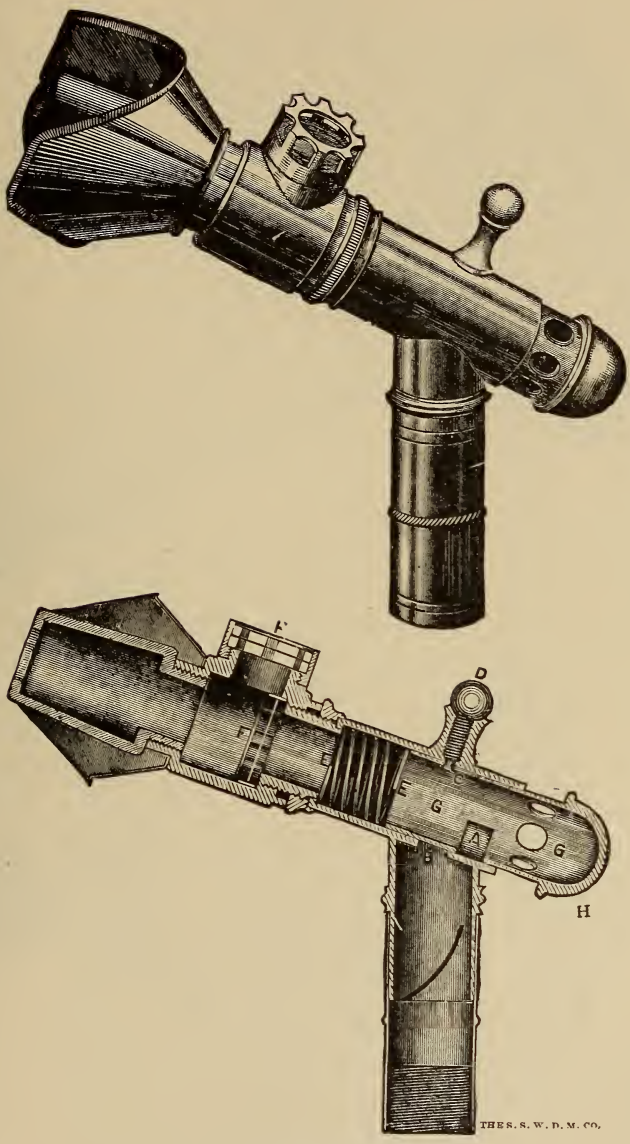


Sectional view of gasometer.

air and accustoms the patient to the kind of breathing required. Then the appliance is placed at a short distance above the mouth and nose so that the vapor will gravitate to them, being careful to allow none of the ether to drop from the cone upon the face, as it would demoralize the patient. The inhaler is to be advanced toward the face slowly and gradually, watching the effect upon the patient; if there is a tendency

to cough, the advance should be interrupted until this has passed. After the cone has closed tightly over the mouth and nose, it is a good plan

FIG. 667

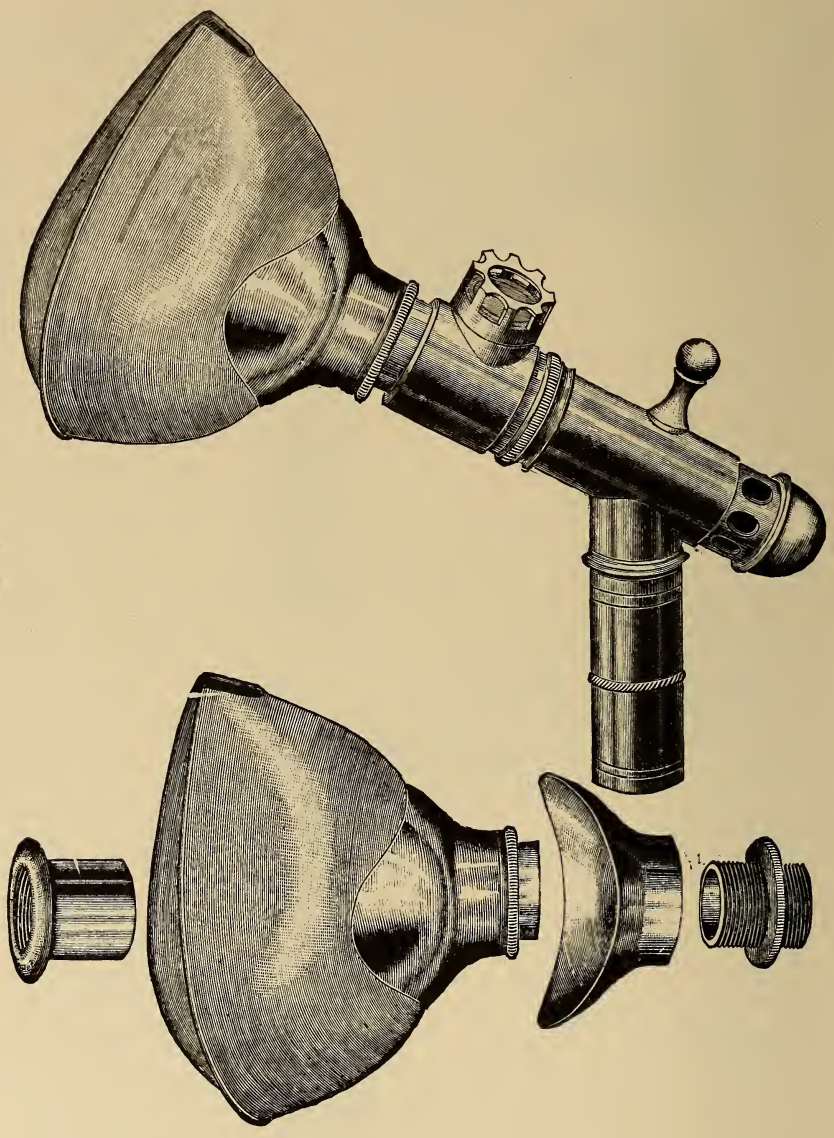


Nitrous oxid inhaler.

to ask the patient to hold up the left hand as long as possible; this will concentrate his thoughts upon the act and away from the operation. When the hand begins to fall, the request to raise the hand should be

repeated; it will soon fall, and in a few seconds afterward, one, two, or three teeth may be removed, the number depending entirely upon their position and the difficulty to be overcome in their extraction. As soon as

Fig. 668

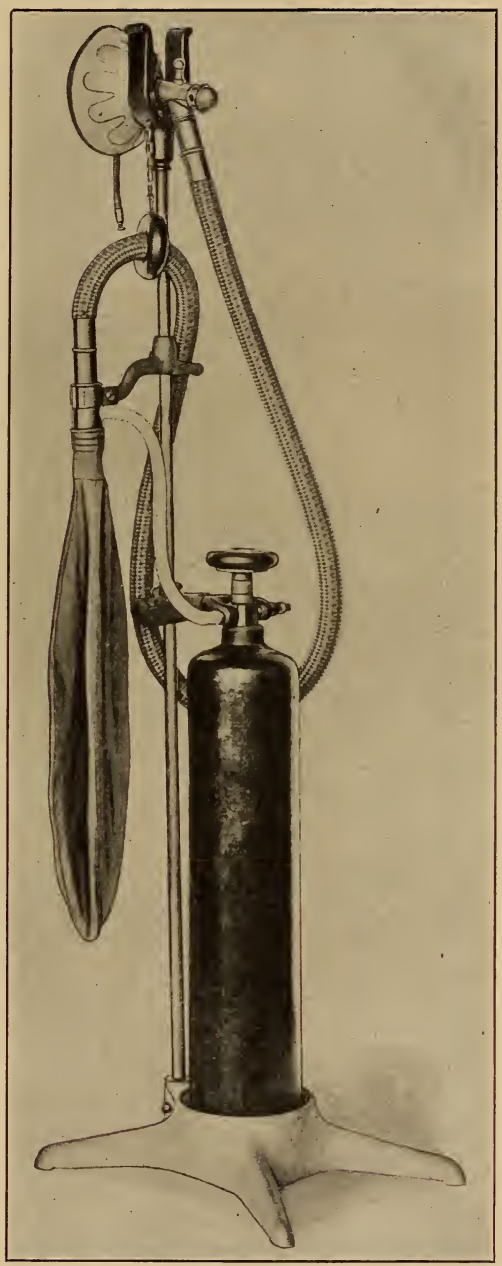


Hood inhaler.

the teeth are extracted the head of the patient should be raised from the head-rest and the body carried forward, and, having a hand cuspidor in front, the patient should be requested to eject the blood from the mouth; this direction is usually complied with. The patient in most

instances recovers in a few moments, and with no disagreeable after-effects; but if the ether is carried beyond the struggling stage to the

FIG. 669

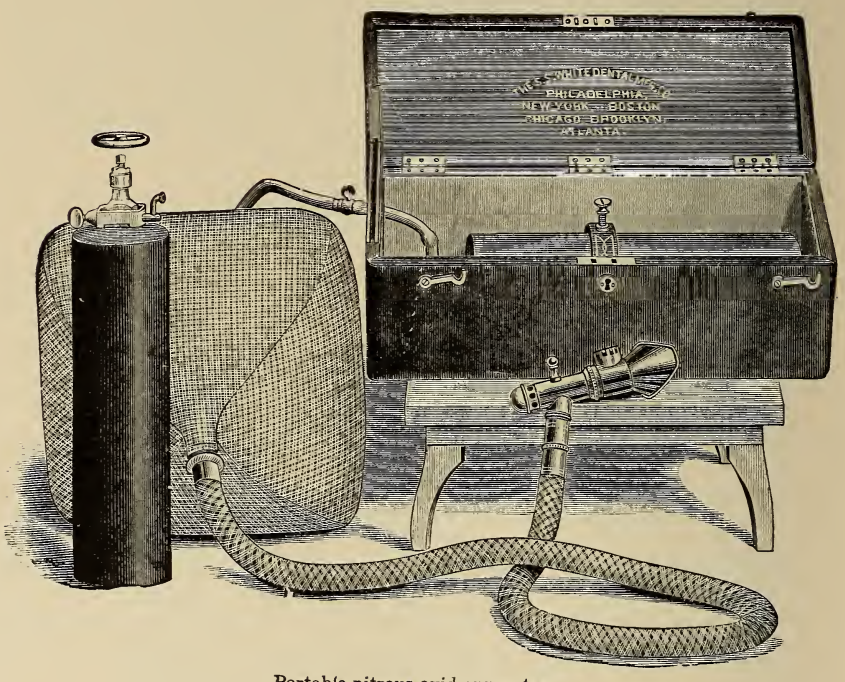


Stand for compressed gas cylinder, gas bag, tube, and inhaler.

point of complete surgical narcosis the nauseating after-effects are very disagreeable unless the patient has been thoroughly prepared for the occasion.

Nitrous oxid is the anesthetic most commonly administered for the extraction of teeth, and under ordinary circumstances is the best. Until lately every operator was his own maker of the gas—this was a great disadvantage—but now it can be procured in a liquefied form compressed in cylinders. There are many different appliances used for the administering of this gas even when using it in a condensed form. One of the most prominent is that shown in Figs. 665 and 666, in which the gas is drawn into a reservoir and then passes through a flexible tube to the mouth-piece (Figs. 667 and 668).

Fig. 670



Portable nitrous oxid apparatus.

The two principal mouth-pieces are Fig. 667, which should have the detachable lip-shield removed so that the tube may be placed directly into the mouth and the lips compressed around the tube by the operator, at the same time closing the nostril by the thumb and finger, and Fig. 668, which is known as a hood inhaler; it is made to cover the nose as well as the mouth. The advantage of the first mouth-piece is that the lips may be closely watched for the change of color denoting oxygen starvation of the blood, which the experienced operator combats by admitting a certain amount of air with the gas as

required. This advantage can be given to the hood inhaler shown in Fig. 668 by having it made of transparent material, such as celluloid. Fig. 670 represents a portable appliance to be used at a patient's home or away from the regular office.

Hewitt's Method.—Sir Frederic Hewitt, of London, England, has devised the apparatus shown in Figs. 671 and 672. The three cylinders contain the compressed gas, two being filled with nitrous oxid and one with oxygen. The valves of the cylinders are opened by a key which is controlled by the foot of the operator. The tube passing from the cylinders to the receiving bag is double, a smaller tube being placed within the outer larger tube. The receiving bag is also double, being divided by a rubber septum into two compartments which have their outlet in the double tube which leads to the inhaler. To the receiving bag is attached a mixing chamber, and to this the inhaling tube or hood is fastened. This appliance is used very successfully in England and has been introduced into the United States. It has proved satisfactory to all who have tried it. The bags and tubing should be made of more durable material when intended for use in the American climate.

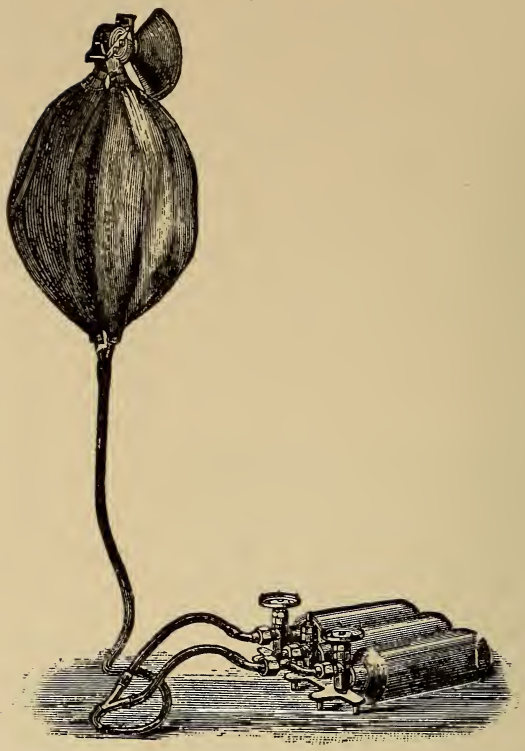
The manner in which the appliance is used is as follows: The valves in the mixing-chamber (Fig. 672) are closed, then oxygen is let into its compartment of the receiving bag until the latter is nearly filled, when the nitrous oxid is admitted into its compartment. The patient being prepared, the inhaling tube or hood is placed in position, and the patient is directed to breathe—long, full, and steadily. If the tube is used it is necessary to close the nose by the thumb and finger.

The valves are not changed for a few inhalations, during which time only air is inhaled; then, pressing the indicator *a* downward to the first notch *b*, the air is cut off, and the patient receives pure nitrous oxid; this is allowed for a few more inhalations, and then the indicator is carried to the next notch and one part of oxygen is allowed to pass into the respiration. When the indicator is carried to the third notch two parts are received by the patient, and so on until the maximum amount of oxygen required by the patient has been reached.

It has been found by careful study of many thousands of cases and by special scientific investigation that the asphyxial condition incident to most cases of nitrous oxid inhalation is quite unnecessary to the production of nitrous oxid anesthesia. It is also justly considered to be subjecting a patient to an unwarrantable danger to permit the asphyxial effect to manifest itself to a profound degree, as in many cases it is a menace to life and health, and might have a fatal effect. The object of Dr. Hewitt's method is to control or eliminate the asphyxial element by administering a requisite amount of oxygen.

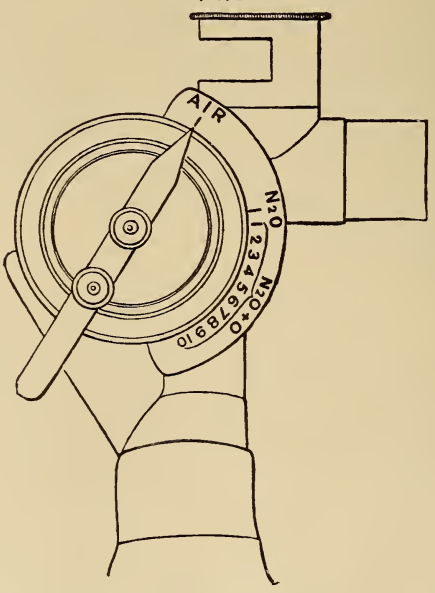
No fixed rule can be laid down for the quantity of oxygen to be added, as each case will require a different amount, and this amount varies during the several stages of the anesthetic procedure. The operator

FIG. 671



Complete apparatus of Dr. Hewitt for administering mixed nitrous oxid and oxygen.

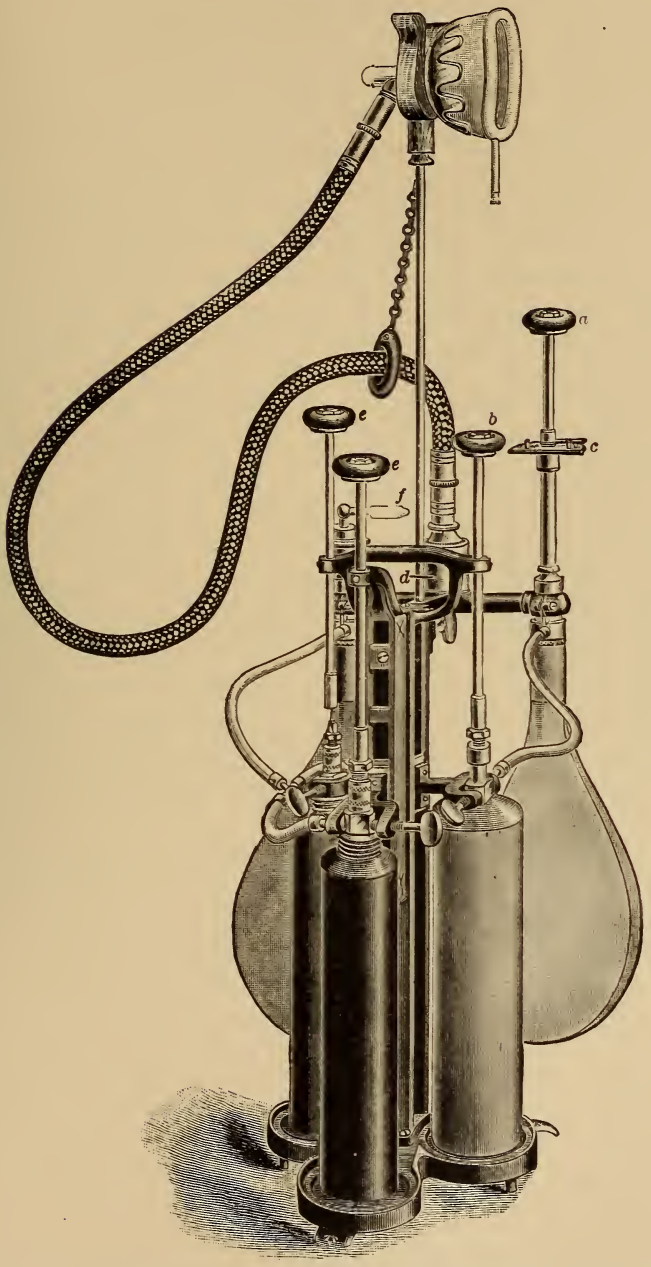
FIG. 672



Showing arrangement of the mixing chamber, with dial and valve for controlling the relative proportions of the gases.

is guided entirely by the symptoms of the patient during the administration, his object being to avoid on the one hand the tendency toward

FIG. 673



Apparatus for administering nitrous oxid and oxygen combined: *a*, key to oxygen bag; *b*, key to oxygen cylinder; *c*, gauge showing percentage of oxygen being administered; *d*, mixing chamber; *e*, *e*, keys to nitrous oxid cylinders; *f*, key to nitrous oxid bag.

asphyxia indicated by cyanosis of the lips, and return of consciousness and sensation on the other hand, which is easily produced by an excess of oxygen. By the admixture of oxygen, as in Dr. Hewitt's method, the anesthesia is somewhat prolonged over the ordinary nitrous oxid method and is slower of induction; but there is entire absence of cyanosis, stertorous breathing, jactitation, or any of the symptoms of asphyxia. The modification of the Hewitt apparatus that has been lately introduced embodies certain features that make it an improvement on the original apparatus. The arrangement of the mixing-chamber in reference to the bags containing the gases is such as to enable the operator to more accurately control the mixture that is administered to the patient. By a turn of the levers *a* and *f* (Fig. 672) any gradation of the gases may be obtained, from pure nitrous oxid on the one hand, to pure oxygen on the other. The construction of the apparatus is such as to better withstand the climatic conditions than the Hewitt apparatus. A brief description will suffice to show the working of the apparatus.

There are three cylinders, two containing compressed nitrous oxid, and the other compressed oxygen.

Two bags, one of black material to contain the nitrous oxid, the other of red material to contain the oxygen.

The key to each cylinder (see *b* and *e*, *e*) opens the valve and allows the gas to pass into its respective bag.

By opening the valve (see *f*) of the nitrous oxid bag the gas passes into the mixing chamber, from which it flows through the covered rubber tube to the inhaler.

When it is desired to combine oxygen with nitrous oxid, open gauged valve (see *a*, *c*) to the oxygen bag; this will admit the oxygen into the mixing chamber. Both gases will pass through the tube to the inhaler.

The proportion of oxygen used will be determined by the degree to which the gauged valve is opened.

By closing the valve of the nitrous oxid bag, oxygen can be given separately.

Similar results are obtained when air is admitted, instead of oxygen, to the patient during the nitrous oxid administration.

CHAPTER XVIII

LOCAL ANESTHESIA

By HERMANN PRINZ, M.D., D.D.S.

Local anesthetics are agents which are employed for the purpose of producing insensibility to pain in a circumscribed area of tissue.

History.—From an historical viewpoint, comparatively few important factors are to be recorded prior to the introduction of cocain for the purpose of locally obtunding pain. The compression of nerve trunks for the abolition of pain seems to be of an old and unknown origin, which was revived by Guy du Chauliac and Ambroise Paré, and indirectly found a permanent place in surgery as the Esmarch elastic bandage. Physically reducing the temperature of a part of the body by the application of cold was instituted much later. Bartholin and Severino introduced this method in the middle of the Sixteenth century. It became a lost art, however, until John Hunter, of London, again called attention to its benefits by demonstrating it upon animals, and Larrey, the chief surgeon of Napoleon's army, employed it for amputating purposes (1807). Through the efforts of Sir B. W. Richardson, in 1866, it was placed upon a rational basis by the introduction of the ether spray. The various narcotics which were employed for internal purposes were also made use of as local applications. Mandragora, henbane, aconite, the juice of the poppy-head, and many other analgesic drugs enjoyed a world-wide reputation. The empirical search for new methods and means pressed the mysticism of the electric current into service, opening a prolific field to the charlatan which even to this day has not lost its charm. Richardson's voltaic narcotism for a time attracted the attention of the medical profession; and Francis, in 1858, recommended the attachment of the electric current to the forceps for the painless extraction of the teeth, and as dental depots still offer appliances of this nature for sale, it seems that the method is still in vogue with some operators. In the early days of modern dentistry we meet with many feeble efforts to alleviate pain during trying operations. Chloroform, alcohol, ether, aconite, opium, the essential oils, and many other drugs were the usual means employed, either simply or as compounds, usually under fanciful names, for such purposes. Snape's calorific fluid, composed of chloroform, tincture of lemon balm, and oil of cloves; nabalus, consisting of glycerite of tannic acid and a small quantity of chloral hydrate; Morton's letheon, which was sulphuric ether mixed with aromatic oils, are

examples of proprietary preparations which enjoyed quite a reputation in their time.

In 1853 Alexander Wood introduced a method of general medication by means of hypodermic injections. At once it was suggested to employ such drugs as morphin or tincture of opium for the purpose of producing local anesthesia. The results were not encouraging, however, until Koller, in 1884, advocated cocain. With the introduction of this drug into therapeutics, local anesthesia achieved results which were beyond expectations, and its adoption created a new era in local anesthesia.

Means of Producing Local Anesthesia.—The term anesthesia (without sensation), which was suggested in 1846 by that great physician-literateur, Oliver Wendell Holmes, to Dr. Morton, is usually defined as an artificial deprivation of all sensation, while the mere absence of pain is referred to as analgesia. Correctly speaking, the term local anesthesia is partially a misnomer. In producing local anesthesia we do not fully comply with all the requirements that anesthesia demands, because a part of the sensorium—the sense of touch, for instance—is not abolished. The term local anesthesia has, however, acquired such universal recognition that it would seem unwise to recommend a change.

Anesthesia may be artificially produced by inhibiting the sensory nerve fibers at their central end-organs in the brain or at their peripheral end-organs in the tissues, thus producing general and local anesthesia. Local anesthesia may be obtained in two definite ways. We may inhibit the function of the peripheral nerves in a circumscribed area of tissue, and we refer to this process as "terminal anesthesia," while if we block the conductivity of a sensory nerve trunk somewhere between the brain and the periphery we speak of it as "conductive anesthesia." Conductive anesthesia may be produced by injecting into the nerve trunk proper—endoneural injection—or by injecting into the tissues surrounding a nerve trunk—perineural injection. The latter form is the usual method pursued when conductive anesthesia for dental purposes is indicated. Specific forms of local anesthesia may also be produced by paralyzing the sensory ganglia in the brain or in the spinal cord; these methods have, however, no bearing on the subject under consideration.

The successful practice of local anesthesia involves the careful coördination of a number of important details, each one constituting a definite factor in itself, which, when neglected, must necessarily result in failure. As a whole, the practice of local anesthesia by the hypodermic method represents a composite of the following factors:

1. A solution of active ingredients in accord with the physical and physiological laws which govern certain functions of the living cell.
2. A carefully selected hypodermic armamentarium.
3. A complete mastery of the technique.

4. A proper selection of the correct method suitable for the case at hand.

5. Good judgment of prevailing conditions.

Physiological Action of Anesthetics.—According to more recent therapeutic conception, it is generally recognized that a drug or a combination of drugs which simultaneously produce local anemia and inhibition of the sensory nerves in a circumscribed area of tissue is the logical solution of the question of local anesthesia. Certain important factors, however, relative to the physiological and physical action of the solution employed for hypodermic injection upon the cell, govern the successful application of such methods. It is of prime importance, therefore, to comply with the laws regulating the absorption of injected solution, *viz.*, osmotic pressure.

If we separate two solutions of salt of different concentration by a permeable membrane, a continuous current of salt and water through the membrane results, which ceases only after equalization of the density of the two liquids, viz., when equal osmotic pressure—according to the Boyle-Van't Hoff's law—is established. The current passes in both directions, drawing salt from the stronger to the weaker solution and water, *vice versa*, until osmotic equilibrium is obtained. The resultant solutions are termed isotonic (De Vries). Osmotic pressure is a physical phenomenon which is possessed by water and all aqueous solutions; it is dependent upon the number of molecules of salt present in the solution and upon their power of dissociation. In organized nature these osmotic interchanges are an important factor in regulating the tissue fluids of both animals and plants. In the animal tissue the circulation depends principally upon the mechanical force exerted by the heart. The life of the cell depends upon the continuous passage of the fluids which furnish the nutrient materials, consisting of water, salt, and albumin. These chemicals are normally present in certain definite proportions. The membrane of the living cell is, however, only semipermeable, viz., the cell readily absorbs distilled water when surrounded therewith; it becomes macerated, loses its normal structure, and finally dies. If, on the other hand, the surrounding fluid be a highly concentrated salt solution, the solution absorbs water from the cell; no salt molecules enter the cell body proper. The cell shrinks and finally dies. This process of cell death is in general pathology referred to as necrobiosis.

A further important factor teaches us that all aqueous solutions which are isotonic possess the same freezing point, viz., all solutions possessing an equal freezing point are equimolecular; they possess equal osmotic pressure. This law of physical chemistry has materially simplified the preparation of such solutions. The freezing point of human blood, lymph serum, etc., has been found to equal, approximately, 0.55° C., which in turn corresponds to a 0.9 per cent. sodium chlorid solution. Such a solution is termed a physiological salt solution. In the older

works on physiology a 0.6 per cent. sodium chlorid solution is referred to as a physiological salt solution; this solution corresponds to the density of the blood of a frog. A slight deviation above and below the normal percentage of the solid constituents is permissible. When physiological salt solution at body temperature is injected into the loose connective tissue under the skin in moderate quantities, neither swelling nor shrinkage of the cells as such occurs; a simple wheal is formed which soon disappears, therefore no irritation results, and in consequence no pain is felt. Other similar bodies which are equally soluble in water act in the same manner, with the exception of the salts of the alkali and earth metals, such as potassium or sodium bromid, for example. The latter substances produce intense physical irritation, followed, however, by prolonged anesthesia, and in consequence are termed by Liebreich "painful anesthetics." If, on the other hand, simple distilled water be injected, a superficial anesthesia only is produced; the injection itself is very painful and acts as a direct protoplasm poison by macerating the cell contents and resulting in severe damage or even death of the cell. If distilled water approximately at the ratio of 10 drams to the pound of body weight be injected into dogs, they will succumb in a short time. The injection of higher concentrated salt solution produces opposite effects; water is removed from the cells with more or less pronounced pain, also followed by superficial anesthesia. The red corpuscles are extremely susceptible to any injected fluid which is not isotonic in its nature. They are universally destroyed (hemolysis) by the injection of fluids which are not represented by an isotonic salt solution. Hypotonic solutions, then, cause swelling of the tissue, while hypertonic solutions produce shrinkage. These manifestations are proportionately the more intense the further the solution is removed from the freezing point of the blood. Furthermore, hypotonic solutions as well as hypertonic solutions require much more time for their absorption than isotonic solutions; the osmotic pressure has to be standardized to the surrounding fluid, viz., to the isotonic index of the tissue fluids. Local anemia or ischemia, viz., a temporary constriction of circulation—presents, as has been experimentally shown, the rapid absorption of fluids which are injected into the affected area.

The more important means to produce local anemia are: (1) The Esmarch elastic bandage. (2) The application of cold. (3) The extract of the suprarenal capsule.

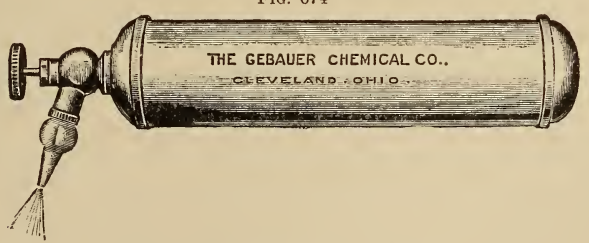
Some observers have maintained that local anemia produces anesthesia. This is not, however, the case; it is merely an important means to confine the injected anesthetic to the anemic region, and thus bring about an increased and prolonged action of the drug. Consequently, the concentration of the anesthetic solution may be of a lower percentage, which, of course, lessens the danger of intoxication. For plausible reasons the Esmarch elastic bandage cannot be made of use for dental operations.

Physically reducing the temperature of the body by the application of cold (ice pack, ice and salt mixture, cold metals, etc.) was practised by the older surgeons. Arnott in 1849 and Blundell in 1855 advocated ice packs for the painless extraction of teeth. Through the efforts of Sir B. W. Richardson, in 1866, this method was placed on a rational basis by the introduction of his ether spray. To obtain good results, a pure ether (boiling point 95° F., 35° C.) free from water is necessary. Certain volatile hydrocarbons possess similar properties in varying degrees, depending on their individual boiling point. In 1867 Rottenstein called attention to the use of ethyl chlorid as a refrigerating agent, and Rhein, in 1889, introduced methyl chlorid for the same purpose. In 1891 Redard reintroduced ethyl chlorid as a local anesthetic, which since has become known by many trade names—as antidolorine, kelene, narcotile, etc.—and mixtures of the first two in various proportions known as anestol, anestile, coryl, metethyl, etc., are extensively used in minor, oral, and general surgery. A pure ethyl chlorid (boiling point 55° F., 13° C.) is best suited for this purpose, as it lowers the temperature of the tissues sufficiently to produce a short superficial anesthesia in a few minutes. Too rapid cooling or prolonged freezing by methyl chlorid (boiling point, 12° F., 24.5° C.) or the various mixtures thereof, produce deeper anesthesia, but such procedures are dangerous. They frequently cut off circulation in the affected part so completely as to produce sloughing (gangrene). Liquid nitrous oxid, liquid or solid carbonic acid (recently known as carbonic acid snow), and liquid air, all of which have a boiling point far below zero, are recommended for similar purposes, but they require cumbersome apparatus and are extremely dangerous.

ETHYL CHLORID AND ITS ADMINISTRATION

Ethyl Chlorid (Monochlorethane; Hydrochloric Ether; C_2H_5Cl).—"A haloid derivative, prepared by the action of hydrochloric acid gas on

FIG. 674



Ethyl chlorid spray tube. (Metal.)

absolute alcohol." At normal temperature, ethyl chlorid is a gas, and under a pressure of two atmospheres it condenses to a colorless, mobile,

very volatile liquid, having a characteristic, rather agreeable odor, and burning taste. It boils at about 55° F. (13° C.) and is very inflammable, burning with a smoky, green-edged flame. It is stored in sealed glass or metal tubes, and when liberated at ordinary room temperature, 70° F. (21° C.), it evaporates at once. In commerce it is supplied in plain or graduated glass tubes of from 3 to 60 grams' capacity, or stored in metallic cylinders holding from 60 to 100 grams or more. To remove the ethyl chlorid from the hermetically sealed small tubes, the neck has to be broken off, while the larger glass and metallic tubes are provided with suitable stopcocks of various designs to allow definite amounts of the liquid to be released.

Mode of Application.—For the extraction of teeth, immediate removal of the pulp, opening of abscesses, and other minor operations about the oral cavity, the tube should be warmed to body temperature by placing it in heated water, and its capillary end should be held about six to ten inches from the field of operation. The distance depends on the size of the orifice of the nozzle, and complete vaporization should always be produced. The Gebauer tube is fitted with a spray nozzle, which shortens the distance to one to two inches, and is especially well adapted for dental purposes. The stream is directed upon the tissues until the latter are covered with ice crystals and have turned white. For the extraction of teeth, the liquid should be projected directly upon the surface of the gum, as near to the apex of the root as possible, but care should be taken to protect the crown of the tooth on account of the painful action of cold on this part. The tissues to be anesthetized should first be dried and well surrounded by a film of vaselin or glycerin, and protected by cotton rolls and napkins, to prevent the liquid from running into the throat. Let the patient breathe through the nose. Occasionally light forms of general anesthesia are induced by inhaling the vapor. On account of the difficulty of directing the stream of ethyl chlorid upon the tissue in the posterior part of the mouth, it is not successfully applied to those regions. The intense pain produced by the extreme cold prohibits its use in pulpitis and acute pericementitis. To anesthetize the second and third branch of the fifth nerve, it is recommended to direct the stream of ethyl chlorid upon the cheek in front of the tragus of the ear, but the author has not seen any good results from such a procedure. Caution should be exercised in using ethyl chlorid near an open flame or in conjunction with the thermocautery, as severe burns have resulted by setting the inflammable vapor on fire.

THE ACTIVE PRINCIPLE OF THE SUPRARENAL CAPSULE AND ITS SYNTHETIC SUBSTITUTES

Within the last decade the active principle of the suprarenal capsule has evoked extensive comments in therapeutic literature. It has been

isolated by a number of investigators under different names, as epinephrin by Abel (1897), suprarenin by Fuerth (1898), and adrenalin by Takamine and Aldrich (1901). Many other titles are given to this chemical—as adnephrin, adrin, paranephrin, suprarenalin, supracapsulin, hemostasin, etc. The *United States Pharmacopœia* (eighth revision) has not as yet admitted this alkaloid to its pages, and, therefore, whenever we refer here to the hydrochloric salt of the alkaloid of the suprarenal capsule, we speak of it as adrenalin, the term which is at present preferred in the United States. Adrenalin is a grayish-white powder, slightly alkaline in reaction, and perfectly stable in dry form. It is sparingly soluble in cold and more soluble in hot water, is insoluble in ether or alcohol, and with acids it readily forms soluble salts. The preparation that is employed mostly for therapeutic purposes is a solution of adrenalin hydrochlorid in a 1 to 1000 physiologic salt solution, to which preservatives—as small quantities of chloretone, thymol, etc.—are added. Adrenalin solution does not keep well. On exposure to air it is easily oxidized, becoming pink, then red, and finally brown, and with this change of color its physiologic property is destroyed. If the adrenalin solution be further diluted, it becomes practically worthless within a few days.

When adrenalin is injected into the tissues, even in extremely small doses, it temporarily raises the arterial blood pressure, acting as a powerful vasoconstrictor by stimulating the smooth muscular coat of the bloodvessels, and thus produces local anemia. Large doses finally reduce the blood pressure, and heart failure results. The respiration at first quickly increases, but slows down and finally stops with expiration. Its action is largely confined to the smooth muscle fibers of the peripheral vessels. Adrenalin is destroyed by the living tissue cells, the body ridding itself of the poison in some unknown manner. While adrenalin does not possess local anesthetic action, it increases very markedly the effect of certain anesthetics when combined with them. These observations are of vast importance in connection with the production of local anesthesia. Carpenter, Peters, Moller, and others referred to the use of adrenalin in this respect, and finally Braun, in 1902, published his classic researches, and to him and his co-workers, especially Heinze and Laewen, belongs the credit of establishing a rational basis for the production of local anesthesia. It is claimed that secondary hemorrhage frequently occurs after the anemia produced by the adrenalin has subsided, and that the tissues themselves suffer from the poisoning effect of the drugs, resulting in gangrene. Such results are produced only by the injection of too large quantities of the drug, which by their deeper action close up the larger arteries. The prolonged anemia will give way to a dilatation of the bloodvessels, and, if the tissues are too long deprived of the circulation, we are able to understand why sloughing may result. Small doses of adrenalin have no effect upon the tissues or

on the healing of a wound. Palpitation of the heart and muscular tremor, which were occasionally noticed in the early period of the use of the drug, are the direct result of too large doses. Recently a synthetic adrenalin has been successfully prepared by Stolz, which, with hydrochloric acid, forms a stable and readily soluble salt. It is known as synthetic suprarenin hydrochlorid. The new chemical has been carefully tested physiologically and in clinical work, and the general consensus of opinion points to the fact that it is not alone equal, but in certain respects superior, to the organo-preparations. Synthetic suprarenin solutions may be readily sterilized by boiling. They are relatively stable, and their chemical purity insures uniform results. They are comparatively free from dangerous side actions. The writer's observations regarding the value of synthetic suprarenin relative to its actions and its general behavior is in full accordance with the above statements, and its advantages over the organo-preparations has led him to adopt it as a component in the preparation of local anesthetic solutions. For dental purposes—that is for injecting into the gum tissue—the dose may be limited to one drop of the adrenalin solution (1 to 1000) or the synthetic suprarenin solution (1 to 1000), added to each cubic centimeter of the anesthetic solution, 5 drops being approximately the maximum dose to be injected at one time.

THE LOCAL ANESTHETICS

Cocain.—Cocain, when injected into the tissues, produces typical local and general effects. Locally, it possesses a definite affinity for the peripheral nerves; it causes constriction of the smaller arteries, producing light anemia in the injected area with diminished action of the leukocytes. However, different parts of the organism require different doses to bring about the same reaction. Upon mucous surfaces, paralysis of the sensory nerves is produced; the senses of touch and smell are temporarily inhibited. The blood as such and the circulation suffer little. If cocain in sufficient quantities is absorbed by the circulation, general manifestations are produced from bringing other tissues in close contact with the poison. The principal disturbances of the central nervous system make themselves known by vertigo, a very soft pulse, enlarged and staring pupils, and difficult respiration. Vomiting may occur; the throat feels dry. Intense excitement is followed by epileptiform spasms; finally, complete loss of sensation and mobility results, which terminates in death from cessation of respiration. The general character of the disturbances is closely related to that which occurs in chloroform or ether poisoning. The typical picture of cocain poisoning is produced when the blood flowing through the central nervous system contains a sufficient quantity of the drug, even for a moment only, which is dangerous

to this organ. No maximum dose can be positively established. This is equally true of chloroform and ether when used for general anesthetic purposes. The many cases of so-called idiosyncrasy probably find an explanation in the too large doses which formerly were so frequently administered.

With our increased knowledge of the action of cocain upon the tissues and a proper technique of the injection, dangerous results are comparatively rare at present. No direct antidotes are known; the treatment of general intoxication is purely symptomatic. Anemia of the brain, which is of little consequence, may be readily overcome by placing the patient in a recumbent position or by complete inversion, if necessary. As a powerful dilator of the peripheral vessels the vapors of amyl nitrite are exceedingly useful; it is best administered by placing 3 to 5 drops of the fluid upon a napkin and holding it before the nostrils for inhalation. Flushing of the face and an increase in the frequency of the pulse follows almost momentarily. For convenience sake, amyl nitrite may be procured in small glass capsules, holding the necessary quantity for one inhalation. Nausea may be remedied by administering small doses of spirit of peppermint, aromatic spirit of ammonia, or validol. The latter is a compound of menthol and valerianic acid and deserves special recommendation. To overcome the disturbances of respiration, quickly instituted artificial respiration is the alpha and omega of all methods of resuscitation; the only drug that has proved to be of value in this connection is strychnin in the form of the sulfate or the nitrate, in full doses by means of hypodermic injections.

The relative toxicity of a given quantity of cocain solution depends upon the concentration of the solution. Reclus and others have clearly demonstrated that a fixed quantity of cocain in a 5 per cent. solution is almost equally as poisonous as five times the same quantity in a $\frac{1}{2}$ per cent. solution. From the extensive literature on the subject we are safe in fixing the strength of the solution for dental purposes at 1 per cent. This quantity of cocain raises the freezing point of distilled water just a little above 0.1° C. To obtain an isotonic solution corresponding to the freezing point of the blood, 0.8 per cent. of sodium chlorid must be added. Having thus prepared a cocain solution which is equal to the blood in its osmotic pressure upon the cell wall, it is now necessary to aid the slightly vasoconstrictor power of the drug by the addition of a moderate quantity of adrenalin, thus increasing the confinement of the solution to the injected area by producing a deeper anemia, for the twofold purpose—(1) to act as a means of increasing the anesthetic effect of cocain, and (2) to lessen its toxicity upon the general system by slower absorption. As stated above, 1 drop of adrenalin solution added to 1 c.c. of the isotonic cocain solution is sufficient to produce the desired effect.

A suitable solution for dental purposes may be prepared as follows:

℞—Cocain hydrochlorid 5 grains (0.30 gm.)
Sodium chloride 4 grains (0.25 gm.)
Sterile water 1 fluidounce (30.00 c.c.)
To each syringeful (2 c.c.) add two drops of adrenalin chlorid solution when used.

Ready made cocain solutions can only be sterilized with difficulty; they will not keep when frequently exposed to the air. Ready made anesthetic solutions as found in the market usually contain preservatives such as phenol, naphthol, boric acid, iodin, essential oils, alcohol, etc., in variable quantities. Some of these solutions have a distinct acid reaction. While they may produce a serviceable degree of anesthesia, they usually damage the injected tissues sufficiently to retard the normal process of wound healing.

Substitutes for Cocain.—Ever since the introduction of cocain into the materia medica for the purpose of producing local anesthesia, quite a number of substitutes have been placed before the profession, for which superiority in one respect or another is claimed over the original cocain. The more prominent members of this group are tropacocain, the eucains, acoin, nirvanin, alypin, stovain, novocain, and, very recently, quinin and urea hydrochlorid. None of these compounds, with the exception of novocain, has proved satisfactory for the purpose in view. The classical researches of Braun have established certain factors which are essential to the value of a local anesthetic. These factors concern their relationship to the tissues in regard to their toxicity, irritation, solubility and penetration, and to the toleration of adrenalin.

There is no need to enter here into a discussion of the pharmacological action of the drugs usually classified as local anesthetics. Let it suffice to state how the above-mentioned drugs fulfil the demands of Braun. Tropacocain is less poisonous, but also less active than cocain, and completely destroys the action of adrenalin; the eucains partially destroy the adrenalin action, and are, comparatively speaking, equally as poisonous as cocain; acoin is irritating to the tissues and more poisonous than cocain; nirvanin possesses little anesthetic value; alypin and stovain are closely related, producing severe pain when injected, which occasionally has resulted in gangrene.

According to Le Brocq, the toxicity of these chemicals may be expressed as follows.

If the toxicity of cocain is taken as the standard and expressed as 1, then that of alypin will represent 1.25; nirvanin, 0.714; stovain, 0.625; tropacocain, 0.5; novocain, 0.49; eucain B, 0.414.

Novocain alone fully corresponds to every one of the above claims. Its toxicity is about two to six times less than cocain; it does not irritate in the slightest degree when injected, consequently no pain is felt from

its injection *per se;* it is soluble in its own weight of water; it will combine with adrenalin in any proportion without interfering with the physiological action of the latter, and it will be readily absorbed by the mucous membrane. The studies of Biberfield and Braun brought to light another extremely interesting factor concerning the novocain-adrenalin combination. Both experimenters, working independently of each other, observed that the adrenalin anemia on the one hand, and the novocain anesthesia on the other hand were markedly increased in their total effects upon the tissues. Consequently, a smaller quantity of this most happy combination is required to produce the same therapeutic effect as a larger dose of each individual drug alone would produce when injected separately. The injection of a solution of the combined drugs is precisely confined to the injected area; general effects are therefore rarely produced.

Novocain.—Novocain is the hydrochloric salt of a synthetically prepared alkaloid, the methyl ester of p-aminobenzoic acid. It is a white crystalline powder, or colorless needle-shaped crystals, melting at 263° F. (156° C.). It may be heated to 200° F. (120° C.) without decomposition. It dissolves in an equal amount of cold water, the solution having a neutral character; in cold alcohol it dissolves in the proportion of 1 to 30. Caustic alkalies and alkaline carbonates precipitate the free base from the aqueous solution in the form of a colorless oil, which soon solidifies. It is incompatible with the alkalies and alkaline carbonates, with picric acid and the iodids. Its solutions may be sterilized by boiling without decomposition.

As stated above, the relative toxicity of a given quantity of cocain in solution depends upon its concentration; this same peculiarity is not shared by novocain. The dose of novocain may be safely fixed at one-third of a grain for a single injection. For dental purposes a 1½ or a 2 per cent. solution in combination with adrenalin has been injected without any ill results. For the purpose of confining the injected novocain to a given area, the addition of adrenalin in small doses, on account of its powerful vasoconstrictor action is well adapted. It is *the* important factor which prevents the ready absorption of both drugs, and consequently largely nullifies poisonous results. An injection of 10 drops of a 2 per cent. solution of novocain labially into the tissue produces a diffuse anesthesia lasting approximately twenty minutes; the same quantity, with the addition of one drop of adrenalin chlorid solution, increases the anesthetic period to over one hour, and localizes the effect upon the injected area.

A suitable solution of novocain for dental purposes may be prepared as follows:

℞—Novocain	10 grains	(0.60 gm.)
Sodium chlorid	4 grains	(0.25 gm.)
Distilled water	1 fluidounce	(30.00 c.c.)

Boil.

To each syringeful (2 c.c.) add 2 drops of adrenalin chlorid solution when used. Fischer strongly advocates the following so-called "normal anesthetic solution," which, when prepared under strict aseptic precautions, and when preserved in amber colored bottles, will keep.

℞—Novocain	23 grains	(1.50 gm.)
Sodium chlorid	14 grains	(0.92 gm.)
Thymol	$\frac{1}{3}$ grain	(0.02 gm.)
Distilled water	3 fluidounces, $1\frac{3}{4}$ fluidrams	(100 c.c.)

Boil.

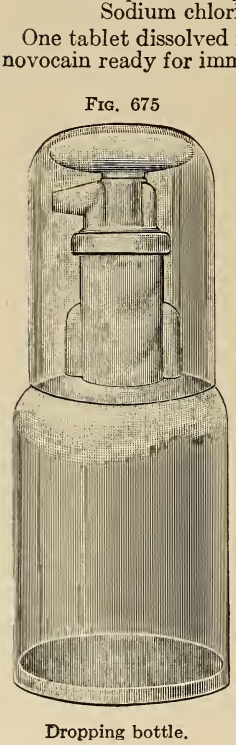
To each c.c. add one drop of synthetic suprarenin solution when used.

A sterile solution may be made extemporaneously by dissolving the necessary amount of novocain-adrenalin in tablet form in a given quantity of boiled distilled water. A suitable tablet may be prepared as follows:

℞—Novocain	$\frac{1}{3}$ grain	(0.022000 gm.)
Suprarenin hydrochlorid	$\frac{1}{200}$ grain	(0.000054 gm.)
Sodium chlorid	$\frac{1}{8}$ grain	(0.008000 gm.)

One tablet dissolved in 20 minims of sterile water mekes a 2 per cent. solution of novocain ready for immediate use.

FIG. 675



Dropping bottle.

Solutions for hypodermic purposes should preferably be made fresh when needed. A small glass dish and a dropping bottle constitute the simple outfit for such work. The dropping bottle should hold from 1 to 2 ounces. A suitable one is made by the Whitall-Tatum Co., of Philadelphia, and may be bought in the drug shops. It should be provided with a dust cap. "A groove on one side of the neck of the bottle, and a vent on the other connected with two grooves in the back of the stopper allow the contents to flow out drop by drop. A quarter turn of the stopper closes the bottle tightly." The water used for making the solution should be boiled and filtered distilled water. The hypodermic solution can be made extemporaneously in a few seconds: Place a tablet in a sterile glass dish, add 20 minims (1 c.c.) of water, and to facilitate the solution, mash the tablet. The solution is now ready for immediate use.

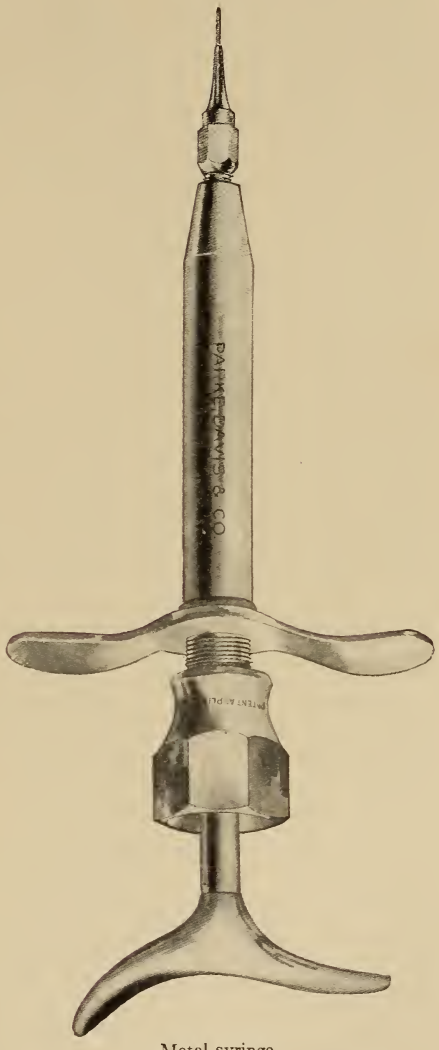
THE HYPODERMIC ARMAMENTARIUM

A hypodermic syringe that answers all dental purposes equally well is an important factor in carrying out the correct technique of the injection. The injection into the dense gum tissue requires from 15 to 50, or even more, pounds of pressure as registered by an interposed

dynamometer, while in pressure anesthesia 100 or more pounds are frequently applied.

The selection of a suitable hypodermic syringe is largely a matter of choice. All-glass syringes,[1] glass-barrel syringes, and all-metal syringes are the usual types found in the depots.

Fig. 676



Metal syringe.

After testing most of the dental hypodermic syringes offered in the dental depots within the last five years by means of the pressure gauge and in clinical work, subjecting the syringes to a routine wear and tear, the author has found that the all-metal syringes of the "Imperial" type are to be preferred over other makes. They are usually made of nickel-plated brass, which, however, is a disadvantage, as the nickel readily wears off from the piston, and exposes the easily corroded brass. The Manhattan all-metal platinoid syringe gives the best general service, and can be conscientiously recommended. The syringe holds 40 minims (2 c.c.) is provided with a strong finger cross-bar, and is extremely simple in construction. The piston consists of a plain metal rod, without a thickened or ground piston-end or packing. The piston-rod is sufficiently long to allow about 2 inches of space between the cross-bar and the piston-top. This space is of importance, as it allows the last drop of the fluid to be expelled under heavy pressure without tiring the fingers. The packing consists of leather washers inserted at the screw point, and are quickly removed and replaced if necessary.[2]

[1] An all-glass syringe that answers every demand regarding asepsis, durability, and perfect construction, is made by Burroughs, Wellcome & Co.

[2] An all-metal syringe has been introduced by Parke, Davis & Co., which is provided with the "Schimmel" aseptic needles and a right-angle attachment for the latter.

The hypodermic syringe requires careful attention. It is not necessary to sterilize it by boiling after each use, unless it should be contaminated with blood or pus. The simple repeated washings with alcohol and careful drying is sufficient. The cap is readjusted, and the piston rod is covered with a thin film of carbolated vaselin or surgical lubricating jelly and placed in position. If the syringe is boiled, all the washers must be removed. The syringe is best kept in a covered glass or metal case; a large bacteriological Petri dish is suitable for this purpose. Leather-lined or felt-lined boxes afford breeding places for bacteria, and should not be used. Some operators prefer to keep their syringes constantly in an antiseptic solution when not in use, and others prefer to place them in a special sterilizing bottle, which bottles may now be purchased at dental depots.

Dental hypodermic needles should be made preferably of seamless steel, or, still better, of nickel-steel, 26 to 28 B. & S. gauge, and provided with a short razor edge point. Thicker needles cause unnecessary pain, and thinner needles are liable to break. Iridioplatinum needles are preferred by some operators, as they may be readily sterilized in an open flame. The needle should measure from a quarter to a half-inch. For infiltration anesthesia one inch needles are necessary, and curved needles of various shapes are essential in reaching the posterior parts of the mouth. The "Schimmel" needles are excellent, but do not, however, fit every syringe. For pressure anesthesia special needles are required, and may be bought at the depots, or quickly prepared by grinding off the steel needle at its point of reinforcement. The sterile needle should be kept in well-protected glass containers. The needles are sterilized after each use by boiling in plain water, dried with the hot air syringe, and immediately transferred to a covered sterile glass dish. The sterile needles should not be again touched with the fingers, and the customary wire insertion is unnecessary.

TECHNIQUE OF INJECTION

Various methods of injecting the anesthetic solution about the teeth are in vogue. For the sake of convenience we may divide them as follows:

The subperiosteal injection.
The peridental injection.
The intraosseous injection.
The perineurial injection.
The injection into the pulp.

Before starting any surgical interference in the mouth, the field of operation should be thoroughly cleansed with an antiseptic solution. A thin coat of the official tincture of iodin painted over the surface is very

useful for this purpose. After the diagnosis is made the method of injection best suited for the case on hand is then decided. The necessary quantity and the concentration of the anesthetic solution is now prepared, and the syringe and hypodermic needle fitted ready for the work. To facilitate the ready penetration of the needle into the tissues, its point may be coated with carbolated vaselin. The correct position of the syringe in the hands of the operator and its proper manipulation is an important factor, and has to be acquired by practice. The hand holding the syringe is exclusively governed in its movement by the wrist, so as to allow delicate and steady movements, and the fingers must be trained to a highly developed sense of touch. The syringe is filled by drawing the solution up into it; it is held perpendicularly, point upward, and the piston is pushed until the first drop appears at the needle point, which precaution prevents the injection of air into the tissue.

The Subperiosteal Injection.—The subperiosteal injection about the root of an anterior tooth is best started by inserting the needle midway between the gingival margin and the approximate location of the apex. The pain of the first puncture may be obviated by a fine, very sharp-pointed needle, the simple compression of the gum tissue with the finger-tip, by holding a pledget of cotton saturated with the prepared anesthetic solution on the gum tissue for a few moments, or by applying a very small drop of liquid phenol on the point of puncture. The needle opening faces the bone, the syringe is held in the right hand at an acute angle with the long axis of the tooth, while the left hand holds the lip and cheek out of the way. After puncturing the mucosa, a drop of the liquid is at once deposited in the tissue, and the further injection is painless. Slowly and steadily the needle is forced through the gum tissue and periosteum along the alveolar bone toward the apex of the tooth, depositing the fluid under pressure close to the bone on its upward and return trip. The continuous slow moving of the needle prevents injecting into a vein. A second injection may be made by partially withdrawing the needle from the puncture and swinging the syringe anteriorly or posteriorly, as the case may be, from the first route of the injection. This latter method is especially indicated in injecting the upper molars. After removing the needle, place the finger tip over the puncture and slightly massage the injected area. A circular elevation outlines the injected field. The naturally pink color of the gum will shortly change to a white anemic hue, indicating the physiological action of the adrenalin on the circulation. No wheal should be raised by the fluid, as that would indicate superficial infiltration and consequently failure of the anesthetic.

As the liquid requires a definite length of time to pass through the bone lamina and to reach the nerves of the peridental membrane and the pulp, from five to ten minutes should be allowed before the extraction is started. The length of time depends on the density of the sur-

rounding structure of the tooth. The progress of the anesthesia may be tested with a fine pointed probe, and its completeness indicates the time when the extraction should be started.

The upper eight anterior teeth usually require a labial injection only, while the molars require both a buccal and a palatal injection, using a slightly curved needle for this purpose. Buccally the injection is made midway between the mesial and distal root, and on the palatal side over the palatal root.

The lower eight anterior teeth are comparatively easily reached by the injection. The straight needle is inserted near the apex of the tooth, the syringe is held in a more horizontal position, and the injection proceeds now as outlined above.

The lower molars require a buccal and lingual injection. The curved needle is inserted midway between the roots, the gum margin, and the apices. The external and internal oblique lines materially hinder the ready penetration of the injected fluid, and therefore ample time should be allowed for its absorption.

If two or more adjacent teeth are to be removed, the injection by means of infiltrating the area near the gum fold directly over the apices of the teeth is to be preferred. It is advisable to use a one inch needle for this purpose, holding the syringe in a horizontal position, so as to reach a larger field with a single injection.

The injection into inflamed tissue, into an abscess, and into phlegmonous infiltration about the teeth is to be avoided. The injection into engorged tissue is very painful; the dilated vessels quickly absorb cocain without producing a complete anesthesia, and general poisoning may be the result. In purulent conditions the injection is decidedly dangerous, as it forces the injection beyond the line of demarcation. If the abscess presents a definite outline, the injection has to be made into the sound tissue surrounding the focus of infiltration. If a tooth is affected with acute diffuse or purulent pericementitis, a distal and a mesial injection usually produce successful anesthesia by blocking the sensory nerve fibers in all directions.

Peridental Anesthesia.—Teeth or roots standing singly, or teeth affected by pyorrhea or similar chronic peridental disturbances, are frequently quickly and satisfactorily anesthetized by injecting the fluid directly into the peridental membrane. This method is known as peridental anesthesia, and its technique is very simple. In single-rooted teeth a fine and short hypodermic needle is inserted under the free margin of the gum, or through the interdental papilla, into the peridental membrane between the tooth and the alveolar wall. Sometimes the needle may be forced through the thin alveolar bone so as to reach the peridental membrane direct. To gain access to this membrane in teeth set close together, slight separation with an orange-wood stick or other suitable means is often found to be of advantage. Two and sometimes three

injections are necessary. To force the liquid into the membrane usually requires a higher pressure than that which is necessary for injecting into the periosteum covering the alveolar process, but the quantity of the anesthetic liquid is less than that which is required for the former injection. Acute inflammatory conditions of the peridental membrane and its sequelæ prohibit the use of this method. Peridental anesthesia is the purest form of local anesthesia, since the seat of the nerve supply of the tooth is very quickly reached, and as a consequence the results obtained are in the majority of cases extremely satisfactory, provided that general conditions justify its application.

Intraosseous Injection.—To facilitate the passage of the injected fluid into the bone structure proper, Otté, in 1896, recommended a method by which he forces the anesthetic solution directly into the spongy cancelloid bone. Otté terms this procedure the intraosseous method of injection, and its technique is described by him as follows: After the gum tissue is thoroughly cleansed with an antiseptic solution, it is anesthetized about the neck of the tooth in the usual manner. After waiting two or three minutes, an opening is made into the gum tissue and the bone on the buccal side with a fine spear drill or a Gates-Glidden drill. The opening should be made more or less at a right angle with the long axis of the tooth, a little below the apical foramen in single-rooted teeth or between the bifurcation in the molars. The right-angle hand-piece is preferably employed for this purpose. The drill should be of the same diameter as the hypodermic needle. The gum fold is tightly stretched to avoid laceration from the rapidly revolving drill. As soon as the alveolar process is penetrated, a peculiar sensation conveyed to the guiding hand indicates that the alveolus proper is reached, and the sensation felt by the hand is about the same as that experienced when a burr enters into the pulp chamber. In this artificial canal the close-fitting curved needle of the hypodermic syringe is now inserted, and the injection is made in the ordinary way. The quantity of fluid used is much less than is usually needed for a subperiosteal injection. The roots of the teeth are embedded in a sieve-like mass of bone tissue (diploë), which allows a ready penetration of fluid when injected under pressure. Very recently, Masselink, advocates this method for the anesthetization of any tooth in the mouth either for the purpose of extraction or the removal of its pulp. He employs a No. $\frac{1}{2}$ round bur for penetrating the alveolar plate and a very short needle (about one-sixteenth of an inch) with a dull point for the injection.

Perineurial Injection.—For the anesthetization of a number of teeth in the upper or the lower jaw, conductive anesthesia by means of perineurial injection is preferably employed. The perineurial injection is made near the point of exit or entrance of the various nerves about their respective foramina. To anesthetize all the teeth of one-half of the upper jaw four injections are necessary, *i. e.*, two bucally and two on

the palatal side of the bone. A one-inch needle is required for such work. To reach the many small branches of the posterior dental nerves at the alveolar foramina, the injection is made buccally over the region of the tuberosity about $\frac{1}{2}$ inch above the gingival line between the first and second molar tooth. The second injection is made below the infraorbital foramen, so as to reach the middle and anterior dental nerves. With the index finger of the left hand the foramen is approximately located by exerting pressure upon the nerve-exit. The lip is lifted up with the middle finger of the same hand and the needle is now inserted between the apices of the cuspid and first bicuspid teeth. The needle is slowly pushed forward until its point is felt beneath the finger tip. To reach the nerve supply of the hard palate one injection is made near the posterior palatine canal, and the other near the foramina of Scarpa. The great palatine nerves pass through the posterior palatine canals on either side of the hard palate. The canals lie about three-eighths of an inch above the edge of the alveolar process and the last molar tooth. They move posteriorly with the eruption of the successive teeth. The nasopalatine nerves pass through the foramina of Scarpa (incisive foramen), which are situated in the line of the suture of the maxillary bones. If an imaginary line be drawn from the distal borders of the two cuspids and passing over the hard palate, the line will ordinarily pass through the foramina. The needle should be inserted directly back of the papilla, which lies posteriorly between the central incisor teeth.

To anesthetize one-half of the mandible, three injections for the deposition of the anesthetic solution are necessary. The first injection is applied near the mandibular foramen, the second near the mental foramen, and the third into the incisive fossa. To locate the mandibular foramen in the mouth, the lingual surface of the ramus is palpated with the finger, the anterior sharp border of the coronoid process is easily felt about five-eighths of an inch posterior of the third molar. The process passes downward and backward of the third molar, and enters into the external oblique line. Mesially from this ridge is to be found a small triangular concave plateau, which is facing downward and outward, being bound mesially by a distinct bony ridge and covered with mucous membrane. As there is no anatomical name attached to this space, Braun has called it the retromolar triangle (trigonum retromolare). In the closed mouth it is located at the side of the upper third molar, and in the open mouth it is found midway between the upper and lower teeth. Immediately back of the mesial border of this triangle, directly beneath the mucous membrane, lies the lingual nerve, and about three-eighths of an inch farther back the mandibular nerve is to be found. This last nerve lies close to the bone, and enters into the mandibular foramen, which is partially covered by the mandibular spine.

Before starting the injection the patient should be cautioned to rest

his head quietly on the head-rest of the chair, as any sudden movement or interference with the hand of the operator may be the cause of breaking the needle in the tissues. The syringe, provided with a one-inch needle, is held in a horizontal position, resting on the occluding surfaces of the teeth from the cuspid backward and slightly toward the median line. The needle is to be inserted three-eighths of an inch above and the same distance back of the occluding surface of the third lower molar, the needle opening facing the bone. This position will insure the correct direction of the needle point so as to reach the tissues immediately surrounding the nerves, and not lose the injection in the adjacent thick muscle tissue. The needle must always be in close touch with the bone, and is now slowly pushed forward, depositing a few drops of fluid on its way until the ridge is reached. About five drops of fluid are injected in this immediate neighborhood for the purpose of anesthetizing the lingual nerve. The needle is now pushed very slowly forward, always keeping in close touch with the bone and depositing fluid on its way, until it is pushed in about five-eighths of an inch. It is important to feel the way carefully along the bony wall of the ramus, as the needle may have to pass over the roughened and bony elevations, which afford attachment to the internal pterygoid muscle. During the injection the syringe should remain in the same horizontal position as heretofore outlined. Soon after the injection, paresthesia of one-half of the tongue on the side of the injection occurs, which is soon followed by anesthesia of the mandibular nerve. Paresthesia of the mucous membrane and half of the lower lip is also established. The pulps of the lower teeth, including the cuspid and lateral incisor and the gum tissue on both sides of the jaw, are anesthetized, including a part of the anterior floor of the mouth. The complete anesthesia of the two nerves also anesthetizes the whole alveolar process in this region. About five minutes are required for the complete anesthetization of the lingual nerve, and at least fifteen minutes for the mandibular nerve. Braun claims that the injection is absolutely free from danger, while Roemer states that danger may arise if the whole quantity of the solution should accidentally be injected into a vein.

Conductive mandibular anesthesia is possible only when the patient can open the mouth sufficiently to allow the ready introduction of the syringe. If the tissues about the third molar are highly infiltrated with inflammatory exudates, local anesthesia is absolutely prohibited.

The mental foramen lies midway between the superior and inferior border of the body of the mandible on its external surface, usually below the second bicuspid teeth. Its opening always faces posteriorly. An injection near this point increases the anesthesia in the bicuspid region. The incisive fossa is a shallow depression on the external surface of the mandible between the cuspid teeth. It may be located by the palpating finger immediately above the chin. A number of small

foramina are found in this region for the passage of nerves and nutrient vessels. The lower incisors may be anesthetized by making injections anteriorly into the incisive fossa and one posteriorly in the region corresponding to the fossa. Usually, peridental anesthesia is to be preferred for these teeth.

Conductive anesthesia is serviceable if a number of teeth have to be removed at one visit. It should be borne in mind, however, that in general only one-half of either jaw should be anesthetized at one sitting, so as to keep the quantity of the injected anesthetic solution within the limits of ordinary dosage.

The Injection into the Pulp.—By pressure anesthesia, pressure cataphoresis, or contact anesthesia, as the process is variously termed, we understand the introduction of a local anesthetizing agent in solution by mechanical means through the dentin into the pulp for the purpose of rendering this latter organ insensible to pain. Simple hand pressure with a suitable instrument, the hypodermic syringe or the so-called high pressure syringe, is recommended for such purposes. Regarding the principles of pressure anesthesia, it should be remembered that we cannot force a liquid through healthy dentin by a mechanical device without injury to the tooth itself. If a cocain solution is held in close contact with the protoplasmic fibers of the dentin, the absorption of cocain takes place in accordance with the law of osmosis. The imbibition of the anesthetic is enhanced by employing a physiological salt solution as a vehicle. On the other hand, living protoplasm reacts unfavorably against the ready absorption of substances by osmosis for two reasons: (1) Its albumin molecule is relatively large and not easily diffusible, and (2) as an integral part of its life it possesses "vital" resistance toward foreign bodies. These latter factors are sufficiently demonstrated by the fact that it is very difficult to stain living tissue. Dehydration of the protoplasm increases the endosmosis of the anesthetic solution markedly.

When we apply the same "pressure" anesthesia upon carious dentin, the above statements do not hold good. We are able to press fluids quite readily through carious dentin. We must bear in mind that such dentin has been largely deprived of its inorganic salts, leaving an elastic spongy matrix in position. By drying out this dentin and then confining the anesthetic solution under a suitable water-tight cover, the pressure applied by the finger is quite sufficient to obtain the results. Colored fluids may be readily pressed through such dentin and even stain the pulp.

In teeth not fully calcified and in so-called soft teeth, pressure anesthesia is more readily obtained, while, according to Zederbaum, the process fails in "teeth of old persons, teeth of inveterate tobacco chewers, worn, abraded, and eroded teeth, teeth with extensive secondary calcific deposits, teeth whose pulp canals are obstructed by pulp nodules, teeth

with metallic oxids in tubules, teeth with leaky old fillings, badly calcified teeth—mainly all from one and the same cause, namely, clogged tubuli. In most cases no amount of persistent pressure will prove successful."

From the foregoing it will be observed that the so-called high pressure syringes possess little merit relative to pressure anesthesia. The pressure which can be produced by a good working all-metal syringe, holding it between the index and middle fingers and forcing the piston with the thumb, amounts to 250 to 300 pounds in the average man. The pressure required in pressure anesthesia to produce a perfect contact is usually much less than the above force.

Methods of Anesthetizing the Pulp.—1. The pulp is wholly or partially exposed: Isolate the tooth with the rubber dam and clean it with water and alcohol. Excavate the cavity as much as possible, and if the pulp is not exposed, dehydrate with alcohol and hot air. Saturate a pledget of cotton or a piece of spunk with a concentrated cocain or novocain solution, place it into the prepared cavity and cover it with a piece of vulcanizable rubber, and with a suitable burnisher apply slowly, increasing continuous pressure from one to three minutes. The pulp may now be exposed and tested. If it is still sensitive, repeat the process. Loeffler states that "this pressure may be applied by taking a short piece of orange wood, fit it into the cavity as prepared, and direct the patient to bite down upon this with increasing force. In this way we can obtain a well-directed regulated force or pressure, and with less discomfort to the patient and operator." Miller described this process as follows: "After excavating the cavity as far as convenient and smoothing the borders of it, take an impression in modelling compound, endeavoring to get the margins of the cavity fairly well brought out; put a few threads of cotton into the cavity and saturate them thoroughly with a 5 to 10 per cent. solution of cocain, cover this with a small bit of rubber dam, and then press the compound impression down upon it. We obtain thereby a perfect closure of the margin, so that the liquid cannot escape and one can then exert pressure with the thumb sufficient to press the solution into the dentin."

2. The pulp is covered with a thick layer of healthy dentin: With a very small spade-drill bore through the enamel or direct into the dentin at the most convenient place, guiding the drill in the direction of the pulp chamber. Blow out the chips, dehydrate with alcohol and hot air, and apply the syringe provided with a special needle, making as nearly as possible a water-tight joint. Apply slow continuous pressure from two or three minutes. With a round bur the pulp should now be exposed, and if still found sensitive, the process is to be repeated.

Recently a method has come into vogue which allows successful anesthetization of the pulp by injecting the anesthetic solution around the apex of the tooth. The spongy alveolar process, which contains

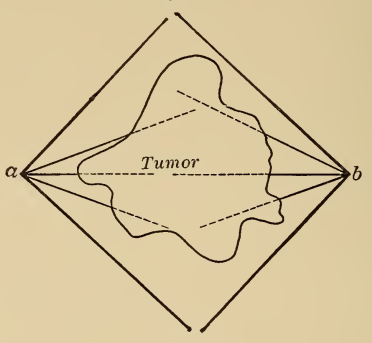
lymph channels, allows the ready penetration of the fluid. The injection should be made close to the bone, pushing the needle slowly toward the apex, while the fluid is deposited drop by drop. No wheal should be raised by the injection, otherwise the benefits of the pressure from the dense gum tissue is lost.

According to Hertwig, the protoplasm of the cell primarily transfers irritation, and, secondly, transmits absorbed materials. Therefore, the anesthetic solution has to pass through the entire dentinal fiber before the nerve tissue of the pulp proper is reached. Consequently a certain period of time is required before the physiological effect of the anesthetic is manifested. This period of latency is dependent upon the thickness of the intermediate layer of dentin or bone. The successful anesthetization of the pulp depends largely upon this most important factor of allowing sufficient time for the proper migration and action of the drug.

LOCAL ANESTHESIA FOR OPERATIONS ABOUT THE MOUTH, EXCLUSIVE OF THE EXTRACTION OF TEETH

In operating about the mouth for an abscess, a cystic or a solid tumor of the approximate size of a large walnut, a malposed tooth, or for any other purpose, the rhomboid infiltration according to Hackenbruch affords the simplest means of producing a most satisfactory anesthesia. After previously cleansing the field of operation with an antiseptic solution, a very small drop of phenol is placed at *a* and *b* (Fig. 677)

Fig. 677



to obtund the point of puncture superficially. The needle is quickly thrust through the mucosa at *a*, and at once slow pressure is exerted on the piston, moving the needle steadily along the external line of the tumor. The needle is now partially withdrawn, without, however, leaving the original puncture, and a second injection or as many as may be needed are made in opposite directions. This maneuver is now

repeated at *b*, and thus a circumscribed infiltration of the whole tumor is obtained. If the tumor, etc., is very large, additional punctures and injections may be made as outlined in the schematic drawing. After ten to fifteen minutes' waiting the extirpation of the tumor may be begun. For injecting the soft tissues other than the gum, a 1 per cent. novocain-adrenalin solution—one tablet dissolved in 2 c.c. of water—is quite sufficient.

The anesthetization of the soft and hard palate is comparatively easily accomplished. The injection on the hard palate is started at the gingival edge of the alveolar periosteum on both sides of the jaw toward the median line. As the gum tissue is extremely dense, great force is required for a complete infiltration in this region, and only small quantities of the solution are required. The soft palate is easily infiltrated by inserting the curved needle posteriorly to the third molar.

Small tumors and cysts on the tongue or the floor of the mouth are best anesthetized by the rhomboid infiltration of Hackenbruch. For the complete extirpation of a ranula, the injection is made into the cyst wall near the periphery, after which the cyst is slit open and a small quantity of the anesthetic solution is injected into the inner surface of the cyst. Large cysts, tumors, and major operations on the tongue require the anesthetization of both lingual nerves. In injecting and operating on the floor of the mouth, the index finger of the left hand should be placed on its external surface as a guide to the needle or the knife.

Local anesthesia is indicated in all minor and in relatively many major operations on the mucous surfaces, the skin, and the teeth. Local anesthesia is not a substitute for general anesthesia; its usefulness is materially increased by familiarizing one's self with the modern methods of its production and with a perfect mastering of the technique. The danger of poisoning has been practically eliminated by using isotonic solutions containing a relative small percentage of the anesthetic in combination with the alkaloid of the suprarenal capsule. Even if the danger of general narcosis is small under the very best conditions, the danger from local anesthesia is always less. The greater majority of all dental operations can be safely carried out under local anesthesia, provided the operator has acquired a complete working knowledge of the various components which, as a whole, constitute this important branch of dental therapeutics.

CHAPTER XIX

PLANTATION OF TEETH

By LOUIS OTTOFY, D.D.S.

The **transplantation** of a tooth signifies the insertion of a natural tooth into a natural alveolus other than the one it originally occupied. The tooth may be an old and dry specimen transplanted into an alveolus from which a tooth has been recently removed, or it may be a freshly extracted tooth transplanted from one part of the mouth of an individual to another part of the mouth of the same individual, or it may be a freshly extracted tooth transplanted from the mouth of one person into that of another.

Replantation signifies the replacing of a tooth in the alveolus whence it had been removed by design or accident. The operation may be performed at once or at any time before the socket is filled with new tissue.

Under the term **implantation** are included all those operations which involve the formation of an artificial alveolus for the reception of the root of a human tooth. The operation of altering the size or form of an existing alveolus to receive a tooth belongs to this class, although it is a combination of transplantation and implantation.

The operation of replantation probably far antedated that of transplantation, as the latter preceded implantation, but its definite history is unknown. It is safe to presume that it has been practised ever since mankind conceived of the natural healing power of the body. Even when performed with crudity and without any clear comprehension of the mode of repair, favorable results have been reported. The operation is at present an uncommon one; the condition for the relief of which it was at one time practised with comparative frequency, chronic alveolar abscess, has been found amenable to less radical treatment.

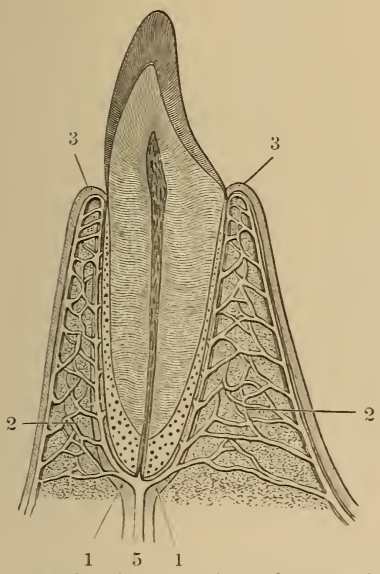
The operation of transplantation is first noted in the writings of Ambroise Paré in the sixteenth century, although credit has generally been given to Dr. John Hunter, who gave the subject considerable attention. Hunter's experiment of implanting a tooth in the comb of a cock is classical. The records of the operation do not exhibit any great measure of success attending it. Hunter noted cases of transplantation of dead teeth which remained for years.

No one disputes with Dr. Younger, of Paris, the authorship

of the operation of implantation. The date of his first operation was June 15, 1885, although Bourdet in 1780 was the first to mention the operation, stating that "irresponsible persons claim to make a socket, and implant into it a tooth." An attempt at partial implantation is recorded in *Dental Cosmos*, vol. xix, p. 258.

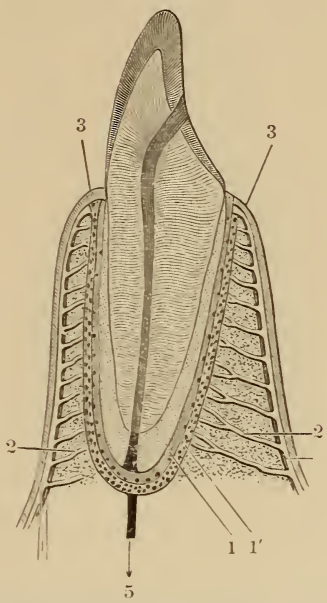
In order that an intelligent conception may be had of the intimate nature of the biological conditions which surround the teeth after insertion by either of these operations, it is essential to study the general processes which attend the repair of tissues, and their behavior toward foreign bodies.

FIG. 678[1]



A tooth and its normal attachment and vascular supply: 1, 1, apical pericementum in which is seen the main pericemental artery, 5; 2, 2, anastomosing bloodvessels or channels of the alveolar walls; 3, 3, the marginal anastomosis of alveolar and pericemental arteries.

FIG. 679



Conditions following replantation: 1, 1′, the pericementum and inflammatory effusion between pericementum and alveolar walls; 2, 2, source of blood supply to the area of repair; 3, 3, terminations of alveolar arteries; 5, obliterated apical artery.

As all of these operations are performed under the strictest antiseptic precautions, the consideration of bacterial influence is omitted at this juncture. As it is impossible to secure specimens which would show these several parts in their true relations, the illustrations are necessarily diagrammatic and theoretical.

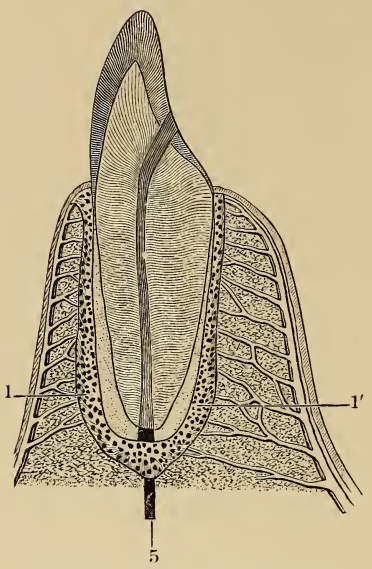
Fig. 678 exhibits a longitudinal section of an incisor, its attachments and support, together with its vascular supply, in its normal relations,

[1] Figs. 678 and 681 are from drawings by Dr. H. H. Burchard.

the bloodvessels from the pericementum anastomosing with those of the alveolar periosteum. The pericemental space is filled with fibrous tissue. To avoid confusion the nerves and veins have been omitted.

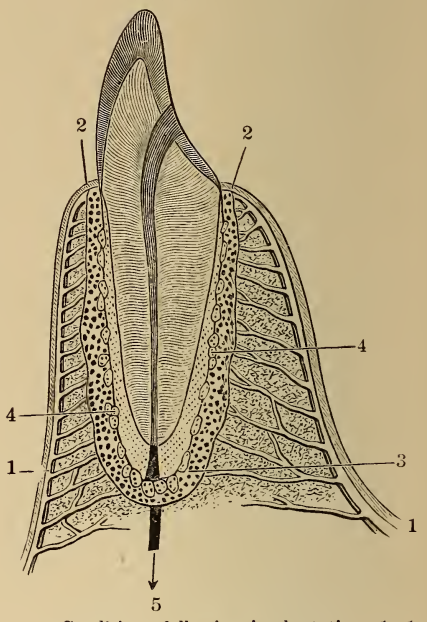
Fig. 679 represents the conditions following replantation. The tooth has been sterilized and its pulp canal hermetically sealed. The pericemental bloodvessels have been destroyed in extraction. Portions of the pericementum are seen clinging as fibrous remnants to the cementum. The remainder of the alveolus is filled with inflammatory cor-

FIG. 680



Conditions following transplantation: 1, 1′, embryonic tissue which will be organized into repair tissue replacing the original pericementum; 5, obliterated apical vessels.

FIG. 681



Conditions following implantation: 1, 1, alveolar arteries; 2, 2, gingival margin; 3, inflammatory still unorganized tissue filling the space between the cementum and walls of the artificial alveolus; 4, 4, phagocytes, multinucleated cells attacking cementum of implanted tooth; 5, obliterated apical vessels.

puscles. The vascular supply to the regenerated pseudo-pericementum is derived first from the vessels of the alveolar periosteum *via* the alveolar process.

Fig. 680 shows the conditions existing soon after the operation of transplantation. The mechanical violence of extraction has irregularly enlarged the natural alveolus. The tooth, its apex rounded, is shown with the blunted extremity. The vascular supply is similar to that of Fig. 679. The alveolar space is filled with inflammatory corpuscles.

Fig. 681 exhibits the conditions probably existent soon after an implantation operation. The vascular supply is the same as shown

in Figs. 679 and 680. Instead of having a layer of periosteal bone, the formation of the artificial alveolus is into the spongy medullary bone. The artificial alveolus, being necessarily different in size and outline from the tooth, is filled with inflammatory products. Some of the cells, becoming multinucleated, are seen to be exercising their phagocytic—in this connection, resorptive—function upon the cementum.

REPLANTATION AND TRANSPLANTATION

Replantation.—In the present state of dental practice the following conditions may be regarded as warranting replantation:

1. When a tooth has been dislodged by traumatism, a blow by a ball, club, or fall, etc.
2. When a tooth has been accidentally removed by the slipping of the forceps during the performance of a dental extraction.
3. When some disease, otherwise incurable, affects either the root or some portion of its alveolus.

The first two causes are practically the most frequent under which replantation is justifiable.

In case a tooth has thus been dislodged and found, it should at once be cleansed of all foreign matter and then be carefully examined for fractures or other injury. Any cavities present should be filled, the contents of the root canal removed, and the space filled in the manner described later; fractured or abraded portions or surfaces are to be made smooth, and the tooth placed in an antiseptic solution. A careful examination of the socket should then be made. It will be noticed when the accident has befallen a young individual, that as a result of the flexibility of the bone, the alveolar process is seldom fractured—an accident more prone to happen in adult life.

Some discrimination should be exercised as to the promptness with which to replant the tooth. If there is considerable inflammation as the result of injury, it is not advisable to replace the tooth immediately. In that event the socket should be made aseptic and if possible normal hemorrhage reëstablished. As a general rule, several days should be allowed to intervene when the inflammation is excessive; otherwise a tooth may be replaced at any time as soon as it has been prepared.

The governing pathological principle is as follows: Immediately after an injury, a certain amount of inflammation takes place and there is retrograde metamorphosis—a destruction or breaking down of tissue; and this is not the most favorable time to expect re-attachment to take place. As a rule, within a few days a building-up process, constructive metamorphosis, has set in, and the replacement of a tooth at this time is likely to be followed by more favorable results. This period sets in

at any time from three days to a week, the socket being then partially filled with active living cells. Just prior to the replacement of the tooth the socket and the gum surrounding it having been cleansed and sterilized, the tooth itself being brought forth from its antiseptic medium, it must be promptly replanted. As a rule, constant but not severe pressure will permit the tooth to assume its original position in the socket, although sometimes it is necessary to remove a part of the apex of the root or slightly deepen the socket by means of a suitably shaped bur. It happens occasionally that the location of the tooth and the general surroundings are such that a tooth like this may be retained without any further attachment, but, as a rule, it is not safe to trust to uncertainties regarding the retention of the tooth. An impression of the tooth and its neighbors can be quickly secured with Melotte's compound or in clay, a die is easily made, from which a cap, such as will be described, is quickly made.

It is needless to dwell upon the second cause mentioned. No dentist can ever be excused for accidentally removing a sound tooth, but in case the accident does happen the above procedure is indicated.

The opportunities enumerated under the third section are also, fortunately, exceedingly rare. The cases in which formerly replantation was resorted to, on the ground that the case was incurable, are now much less frequently met with, and when they are encountered they often yield to treatment, which is now more clearly understood—such as amputation of the root, removal of the necrosed portion of the alveolar process, etc. When, however, it has been decided to extract a diseased tooth and to replant it, diseased portions of the root should be removed and a sufficient time allowed to elapse before replantation for the socket and tissues to have assumed a healthy aspect, even if this should necessitate the enlargement of the socket.

In case of pyorrhea alveolaris, which sometimes has been suggested as coming under this class, treatment by replantation is out of the question, provided the case has made sufficient progress to suggest such a course. Replantation implies the presence of a socket, and when pyorrhea alveolaris has made any great degree of progress, the socket is wanting. Hence it is but in rare cases that an attempt to cure by this method is justifiable.

Dr. Louis Jack[1] has recorded marked success in several cases attending an operation of modified replantation for the cure of some of the earlier phenomena of phagedenic pericementitis, notably the common malposition due to what has been termed voluntary tooth movement.

Transplantation.—There is a broader range for the practice of transplantation than either of the other operations treated in this chapter. As has been seen, replantation is limited in its application, and implan-

[1] See Transactions Academy of Stomatology, 1895.

tation must, from the nature of the operation, be also confined to a comparatively circumscribed sphere.

The operation may be performed at any period of an individual's life, although, as a rule, young, vigorous, and mature adult life offers the greatest promise of success. Any socket in any part of the mouth, when placed in a healthy condition, is a more or less favorable location for the reception of a tooth about to be transplanted. It is true that sometimes a socket needs to be enlarged or deepened for this purpose, but this is a comparatively simple matter. Before the advent of the intelligent practice of crown-and-bridge work, treatment of diseases of the pulp and peridental membrane, the bleaching of teeth, and the intelligent practice of orthodontia, transplantation was resorted to as a remedy for the correction of many trivial disorders. In the light of the present day, transplantation is confined to sockets whence teeth have been removed for any cause which could not be remedied by some other method of treatment—sockets which remain as the result of the loss of teeth from accident of any kind (the lost teeth not having been recovered); from which roots beyond salvation have been extracted; from which diseased teeth must be removed; from which roots have been removed, having carried crowns or having served as abutments for bridges until their period of usefulness has passed.

The same rule laid down for the care of a socket previous to replantation holds good for transplantation; namely, that inflammation must be reduced, and the tooth transplanted into the socket at a time when progressive constructive metamorphosis is taking place. This period is stated as usually from three to seven days after the removal of the tooth. In instances where considerable disease, such as a chronic alveolar abscess of years' standing has been present, even a longer time should be allowed to intervene before transplantation.

PREPARATION OF TEETH FOR PLANTATION

With the exception of such special directions as are necessary in each class of the operations described in this chapter, the following general directions are applicable to all cases:

The Scion Tooth.—For replantation a recently dislodged tooth is supposed to be at hand, hence there is a fresh tooth. For transplantation it is implied that the tooth is either at hand or about to be secured, but in a case of transplantation or implantation the age of the tooth may be unknown and indefinite. Teeth have been planted whose age and origin have been absolutely unknown, and they have become firm in their new locations. Nevertheless it seems reasonable to take the ground that whenever it is possible, teeth should be fresh and something of their previous environment should be known. There are no

cases on record where disease has been transmitted through the medium of a planted tooth, although portions of the early literature of this subject do indicate such results. The principal objection to old and dry teeth is that, the water having been evaporated, these teeth are almost invariably fractured or cracked from shrinkage. When these fractures extend to the crown portion, the enamel frequently chips off within a short time after the tooth has been planted; while in some instances the entire root has been fractured. Another objection to teeth promiscuously gathered is that it is seldom possible to find teeth in which the crowns are sufficiently perfect to be serviceable and to be presentable in the mouth. The crown of a dry tooth permits of but slight alteration with the grinding stone or sandpaper disk without endangering its integrity; while if it is affected by caries to such an extent as to require an extensive operation, the life of the filling is likely to be of shorter duration than a similar operation performed on a freshly extracted tooth or a tooth with living connections. For this reason it is preferable to use only the roots of teeth, attaching to them artificial crowns. This permits the selection of a crown suitable in size, color, and shape, and which may be ground for articulating purposes—an important matter in these cases.

If, therefore, an old, dry tooth must be used, let it be carefully selected with regard to the absence of checks or cracks or fractures, and if it be impossible to secure a tooth with such a crown, let there be selected a good root to which a crown, as described later, can be attached.

If a freshly extracted tooth can be secured, even though the crown may be slightly carious, the necessary filling operation is advisable, and such a tooth should be used, if possible.

Root-filling.—Roots may be filled either from the apex or through an opening or cavity in the crown. Gutta-percha seems to answer all the necessary purposes, but for a short distance from the apical extremity it is well to fill with gold wire or foil.

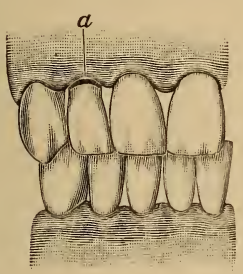
Pericementum.—The theory that the pericementum becomes revivified does not seem to be tenable; at least the proposition that life is maintained in the pericementum for any considerable period of time after the tooth has been removed from vital attachment is not in accord with general physiological laws, although periosteum as a tissue, maintains its vitality for a time after separation.[1] For the purpose of securing an attachment there is no necessity for the presence of the pericementum; but it is reasonable to assume that the nearer to natural states the root and the socket are in, the more favorable will be the prognosis. It is, therefore, a safe rule to follow, to preserve as much of the pericementum as is possible. The preservation of the pericementum has an advantage from the fact that after the tooth has been

[1] See Ziegler's General Pathology.

planted, the pericementum under the influences of bodily heat and moisture expands and thus acts in the nature of a sponge graft, enabling the tissues more quickly to obliterate spaces which are present and to attach themselves to the root.

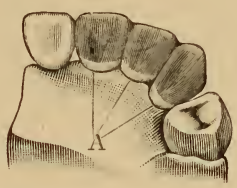
Subsequent Care of Planted Teeth.—Numerous methods for the retention of planted teeth have been recommended by various authors at different times. While many of them are original and ingenious, all are to be condemned except those means which look to the firm, rigid, immovable retention of the planted tooth for a definite period, that of surgical repair. Neither the rubber-dam splint, silk ligature, nor gold or other metal wire comes under this heading. Planted teeth must be retained immovably for a period of two to six weeks, occasionally from two to eight, ten, or twelve weeks. The shortest time of immobility consistent with subsequent attachment is preferable. The tooth to be transplanted or implanted should be fitted after preparation in a model, made from an impression of the gum where the tooth is to be planted and of the adjoining teeth, as shown in Fig. 682.

FIG. 682



Model showing prepared tooth in place: (*a*) gold filling at cervical joint.

FIG. 683



Model showing retention cap in situ.

An impression is then taken of it and of the adjoining teeth on each side. A retention cap is then swaged to cover the grinding surfaces of three or more teeth, half the length of the crown on the labial surface and nearly the full length on the lingual or palatal surface, as shown in Fig. 683.

The cap may be made of pure gold, platinum, or German silver. The gauge, according to the metal used, should be from No. 32 to No. 38. This cap is cemented upon the crowns adjoining the planted tooth in such a manner that it may be removed without disturbing the planted tooth. The operator can remove the cap by springing the metal away from the teeth, examine the condition of attachment of the planted tooth, and replace the cap if it should be necessary. When the articulation interferes with the retention of the cap, the latter may be ligated to the adjoining teeth in addition to being cemented to them, and still admit of removal without disturbing the planted tooth. There

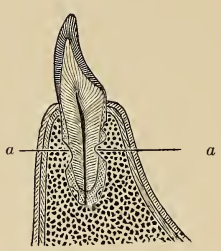
is at present no method of ligaturing or banding the teeth which will permit removal of the ligature or band without more or less disturbance of the planted tooth.

Aside from the necessity of immobility for a certain period, the planted tooth and surrounding tissue generally require but little attention. In occasional cases the tissues may be stimulated by painting the gum with a mixture of equal parts of tincture of aconite root, chloroform, and iodin paint (the latter is a saturated solution of iodin in alcohol), or by the use of stimulating mouth washes, notably those containing capsicum. The patient should be cautioned to encourage the downward growth of the gum by the use of the toothbrush, to prevent the accumulation of remnants of food or saliva, and to prevent their subsequent putrefaction should particles become unavoidably lodged around the tooth or cap. This is best accomplished by using a camel's-hair brush dipped in hydrogen dioxid or pyrozone, electrozone, phénol-sodique, etc., and washing out the interstices frequently. A syringe or spray from an atomizer may be used.

Artificial Roots.—Experiments have been performed looking toward the use of roots other than those of natural teeth. Roots made of ivory, corrugated or perforated porcelain, lead, gold, platinum, and other metals have been used. The writer's experiments in this direction have all resulted in failure. There is no recorded evidence that any have resulted successfully.

Mode of Attachment.—As to the mode of attachment of planted teeth the subject is clouded in obscurity. From the nature of the conditions it is difficult to secure definite information. Dr. Younger holds to the belief that the pericementum becomes revivified, and hence the attachment is almost physiological. It is probable that the filling of the space around the root of the tooth with compact bone tissue is sufficient to account for the retention of the tooth by bony encapsulation or ankylosis. It is probable that a planted tooth, by reason of the absence of the cushion formed by the living pericementum, causes more or less irritation in the socket through the impact of use in mastication, and that this irritation leads to resorption of the root; that in this resorption and the subsequent filling up of these resorbed surfaces are found reasons for the success of the operation. Fig. 684, at *a*, *a*, shows how a partially resorbed root may be retained in place. The length of time during which a planted tooth is retained depends entirely upon the rapidity of the resorptive process and the activity of the tissues in maintaining a healthy condition. Replanted and transplanted teeth

FIG. 684



An implanted tooth in situ: *a*, *a*, excavations of the cementum due to resorptive process.

have been known to do good service for from twenty to forty years. The time of the observation as to implanted teeth is shorter, the oldest cases being less than twenty years old. In the writer's observations, extending over a period of nearly eighteen years, a number of teeth have been noted which have been retained successfully for ten years; how much longer they will remain serviceable, and what percentage of success will attend later cases, will require further time to determine. Dr. Younger has had successfully implanted teeth under observation, at last report, for eleven years.

Precautions.—There is no special danger connected with any of the operations described in this chapter, provided the usual antiseptic precautions are observed and dangerous anesthetics avoided. Aside from these, during the operation of replantation and transplantation no special skill is necessary; certain precautions are, however, essential. Inasmuch as implantation is an essentially esthetic operation, it should be borne in mind that it is confined principally to the ten anterior teeth, and that it is more frequently performed in the upper jaw than in the lower. The territory involved is therefore limited. The operator who contemplates forming in this territory a socket for the reception of the root of a tooth should be intimately acquainted with the anatomical and histological relationships of the various parts.

In the first place it should be remembered that when alveolar resorption has taken place, the relative depth of bone is considerably less than when a tooth is still *in situ* and surrounded by the normal alveolar process. The operator must, therefore, not penetrate deeper into the bone than the original depth of the socket may have been. Indeed, it is not, as a rule, necessary to penetrate so far.

In the upper jaw the principal danger in making a socket for the reception of central incisors lies in the proximity, posteriorly, of the anterior palatine nerve, artery, and vein, which have their exit from the bone through its foramen, often near the roots of these teeth. With the lateral incisor the principal precaution necessary is the preservation of the labial plate of the alveolus. If the lost tooth has been absent for some time, and much resorption has taken place, it is sometimes impossible to drill a socket so that the tooth has a proper direction and prominence in the arch, and yet be able to secure a bone covering for its labial surface. As a rule, there is sufficient process in the canine region to enable the operator to secure all the attachment desirable. The bicuspid and molar regions present the danger of perforation of the floor of the maxillary sinus. This is liable to happen anywhere from the first bicuspid to the second molar. Extreme caution should be exercised to avoid it. In two instances in practice the perforation was followed by no unpleasant complications. Care was taken not to infect the sinus, the teeth were implanted in the usual manner, and the cases resulted successfully. Subsequently one of these teeth was

lost, but during the process of root attachment or encystment the perforation into the sinus was closed.

In the lower jaw the principal difficulties encountered are the following: In the incisive region there is a deficiency of alveolar process, and hence much difficulty is encountered, at times, in securing a sufficiently deep bony socket. At the location of the canine tooth the lower jaw becomes broader and there is usually sufficient room to enable the making of a good socket. In the premolar region the principal precaution necessary is in regard to the mental foramen. It must be borne in mind that normally the exit of the nerves and vessels at this point is directly below the second bicuspid tooth, and that when resorption of the alveolar process has taken place this foramen is often near the upper border of the jaw. From this point posteriorly implantations are rarely performed, and when done the principal precaution must be in regard to the inferior dental canal, which is near the surface if much resorption has taken place.

Artificial Crowns.—The precautions necessary in the selection of a tooth for transplantation or implantation have been noted, and it might be proper at this time to describe the preparation of a root with an artificial crown, presuming that it is only in rare instances that a suitable entire natural tooth can be obtained. Attention was called to the necessity of securing asepsis of the root, and the filling of the root canals has been described. The most suitable form of crown has been found to be the Logan, which is ground to suit the occlusion and cemented into the root canal without much regard as to a careful fit at the cervix of the crown to the root. After the cement has hardened, the margin between the root and crown is prepared with engine burs, and a filling of gold introduced, making a circle around the tooth. When this is polished down there is a perfect gold filling level with the root and crown, which is preferable to a soldered band (Fig. 685).

FIG. 685



Natural root with artificial crown.

A similar result may now be much more satisfactorily obtained by adapting the crown to the root end with casting wax and, after carefully trimming to shape, withdrawing the crown with lid attached, investing the whole and replacing the wax by a gold casting by means of any of the modern casting machines.

GENERAL CONSIDERATIONS

Asepsis.—The operations described in this chapter must always be performed under perfect aseptic conditions; that is, the hands and person, instruments and other accessories, the tooth about to be planted,

and the field of surgical operation must be maintained in a clean, aseptic condition.

Any of the usual, accepted methods can be resorted to. As a rule, however, the drugs selected for this purpose should not be of an irritating nature. For the hands and person, pure soap followed by a 5 per cent. solution of carbolic acid is sufficient. The instruments and other accessories can be kept free from inoculating bacteria by the use of pyrozone, formalin, euthymol, or a 5 per cent. solution of carbolic acid. The use of bichlorid of mercury in the proportion of 1 part to 2000 of water is also permissible, although it is not as advisable on account of its irritating nature. The sterilization of the tooth about to be planted differs according to circumstances. A tooth whose source is unknown, and which has been kept in a dry state for a long period, will not be benefited by being placed into an antiseptic solution until just prior to the time when it is to be used. Hence dry teeth can be kept in any clean box covered with clean cotton until they are ready for use. After the necessary preparation hereinafter described, the dry tooth should be placed in a solution of glycerol and carbolic acid (about 5 per cent. of the latter), and just before using, it can be placed in a pyrozone solution or in a solution of carbolic acid and water. Freshly extracted teeth should, of course, have their pulp chambers and root canals cleansed and hermetically sealed, and then be placed at once in fluid, preferably in diluted glycerol to which a few drops of carbolic acid have been added. Teeth and roots so treated have been preserved for eight years.

The field of operation may be quickly sterilized and cleansed of adhering mucus by mopping the surface with a ball of cotton saturated with hydrogen dioxid, 3 per cent. solution, just previous to operating.

It is, of course, of exceeding importance that the socket into which a tooth is about to be planted shall be free from disease germs or bacteria. As a general rule, flowing blood is the best of antiseptics, washing away any bacteria which may become lodged from external sources; hence so long as a socket is constantly being filled with flowing blood during an operation but little further care need be bestowed upon it. As a general rule, the socket and the tissues surrounding it will react more quickly after operation the less the medication has been; hence the very slightest and mildest of antiseptics are indicated. Zinc chlorid 2 to 5 grains to the ounce of lukewarm water, hydrogen dioxid, 3 per cent., or the 5 per cent. solution of carbolic acid in lukewarm water, give most satisfactory results. These solutions will be found quite sufficient to maintain the field of surgical operation aseptic.

Anesthesia.—For the purpose of allaying pain, the use of anesthetics is justified when imperatively demanded; but unfortunately in certain cases the benefits derived are frequently outweighed by the disadvantages accruing from their use.

Anesthetics are either general or local. An operator would scarcely be justified in assuming the risks attendant upon the use of chloroform, ethylic ether, ethyl bromid, or any of the combinations in which these anesthetics are administered. Nitrous oxid would, in the majority of instances, be contraindicated by reason of the shortness of the period of anesthesia which it induces.

There do not appear to be any records of satisfactory results with hypnosis. Local anesthesia, therefore, is the means generally employed.

The method adopted has usually been confined to the injection or other introduction of cocain, the dose being variable, but usually about 5 to 15 minims of a 1 per cent. solution of the hydrochlorid. For a full description of the technique consult Chapter XVIII on Local Anesthesia. A serious objection has been noted to injection through the gum, viz., that more or less sloughing or destruction of the tissues may result, and this is very unfavorable for subsequent success. In replantation or transplantation, sufficient anesthesia is often obtained from the wash used in cleansing the socket; but in implantation the formation of the new socket is often an exceedingly painful operation, and in these cases good results may be had by dipping the instrument with which the socket is being made into crystals of cocain, and thus by the friction of the instrument rubbing it into the parts that are being operated upon.

The subject of anesthesia may be dismissed with the sole injunction that its use should be resorted to only in those instances where it is absolutely necessary. The majority of the cases of plantation are performed with no more pain than is inflicted in filling operations.

The same care should be given to the retention of transplanted teeth as is given to the retention of replanted teeth. Teeth thus carefully transplanted, in individuals of good health, often remain useful for a number of years. In the past insufficient attention has been given to asepsis, and this, coupled with the fact that the root had not always been properly filled, has not resulted in as much success as is attained with present methods, and yet transplanted teeth are known to have remained in a healthy and serviceable condition for from twenty to forty years.

THE OPERATION OF IMPLANTATION

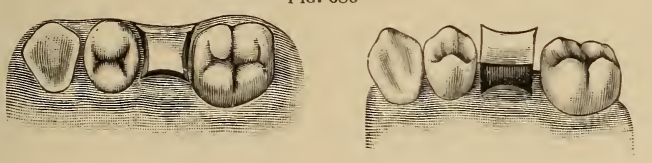
Implantation, in order to yield the best results, should be confined to mouths which are habitually clean and free from disease, and to a part of the individual's life during which the power of the developed mental processes is not impaired. Unclean personal habits, the excessive use of stimulants, and occupations calling for an unusual expenditure of nerve force are unfavorable. A suitable case having

been selected, an impression of the space and of the teeth adjoining it is taken. A plaster cast is made, the proper-sized socket drilled therein, the tooth is selected and prepared, either with or without an artificial crown in the manner previously described, the occlusion is adjusted, and a retention cap is made. These preliminaries having been satisfactorily accomplished, the case is ready for the operation. Under the heading of General Considerations the question of anesthesia has been already treated.

The first step in the operation is the making of an incision through the gum tissue. A number of different kinds of incisions have been recommended by different operators, nearly all of them looking toward the preservation of the largest amount of gum tissue. Some recommend a crucial incision X, turning back the four corners of the gum tissue. Others have recommended an incision in the shape of the letter H, turning back the two flaps thus made.

The principal objection to all of the incisions recommended lies in the fact that they all look toward the preservation of the gum tissue equally for the labial and lingual surfaces; while, as a matter of fact, if proper provision is made for the protection of the cervical line on the labial surface, the lingual surface will take care of itself, for it will be noticed in cutting through the gum tissue that it is much thinner where it reflects over the alveolar border upon its labial aspect than upon its lingual. Hence, frequently, if no attention whatever has been paid to the retention of gum tissue on the lingual surface, the neck of the tooth will nevertheless be sufficiently protected.

FIG. 686



Incision in gum for implantation.

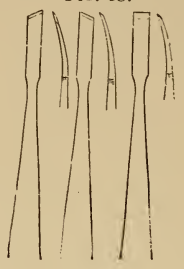
Another serious objection to an incision which leaves two or more points or margins to be preserved, is that the tenacity of the gum tissue makes it utterly impossible to preserve these various flaps and projections intact from the cutting instruments.

The writer's method consists in an incision resulting in one flap, with a view of protecting the labial surface of the tooth to be implanted, and of preserving this single flap from injury during the progress of the operation. A combination, or rather a modification, of the most suitable incisions recommended is, therefore, the one shown in Fig. 686.

This incision is made with ordinary chisels as shown in Fig. 687,

cutting with the chisel to and including the periosteum, lifting it forward and holding it out of the way of the operator by means of an instrument

Fig. 687



Chisels.

Fig. 688



Instrument for holding flap during the operation.

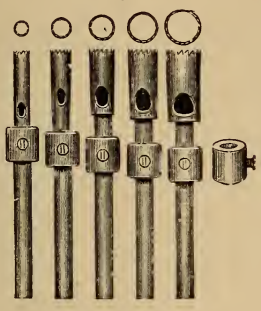
similar to the one shown in Fig. 688. The operation thus far is usually simple and, as a general rule, not very painful. The drilling of the socket varies with different individuals according to the density of the bone, the length of time that the tooth has been out, etc. In some instances, the reamer or trephine or knife progresses rapidly, while in others the progress is very slow, or sometimes variable as the instrument enters into medullary spaces or passes through the more or less dense partitions which divide these medullary spaces from each other.

The operator will determine during the operation, by the progress he is making with different instruments, which are the best to use. In some instances the entire socket can be made with an ordinary engine bur, while in others the strongest instruments especially designed for implantation are none too strong. In some instances an instrument which clears itself well during one operation clogs annoyingly during another. It is desirable to describe at this point the various useful instruments which have been designed and are now upon the market. While all of them are not necessary, some one or more of each class are indispensable. The trephines of Dr. Younger, of Paris, which have been improved by Dr. W. W. Walker, of New York, have (as shown in Fig. 689) a set-screw collar, also shown detached, which slides on the shank, and is first fixed by a set-screw as a gauge of the length of the tooth root. As will be noticed, the trephines cut only on the edge, and hence they do not entirely clear themselves; the reamers described on a succeeding page are then used to remove the core and enlarge the socket.

The spiral knives (Fig. 690) devised by Dr. W. H. Rollins, of Boston, are in many cases very useful.

They are also open to the objection of clogging. As an improvement upon these the spiral crib knife shown in Fig. 691 has the advantage of permitting the core to pass within it.

Fig. 689



1 2 3 4 5

Younger-Walker trephines.

Fig. 690



1 2

Rollins' spiral knives.

Dr. R. Ottolengui, of New York, has devised a set of reamers (Fig. 693). There are nine leaves to each reamer and each leaf is divided into five teeth. Three of the leaves reach the apex of the cone point

Fig. 691.



1 2

Ottofy spiral crib knife.

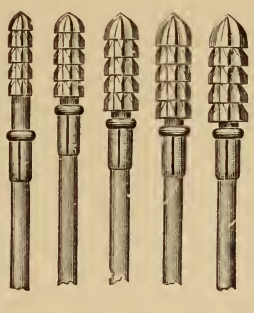
Fig. 692



1 2

Two forms of Cryer's spiral osteotome.

Fig. 693



1 2 3 4 5

Ottolengui's reamers.

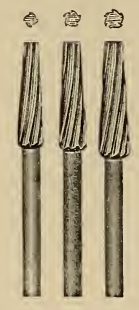
and thus allow a more rapid forward drilling into the bone. A sliding collar forms a gauge to indicate the proper depth to drill.

The reamers designed by Dr. Younger, illustrated in Fig. 694, are also very suitable for this purpose. Dr. Cryer's spiral osteotome—two forms of which are shown in Fig. 692, one with dentate edges, the

other without—is an admirable instrument for forming the artificial socket.

When it is necessary to deepen or alter the shape of the socket, it is done very simply with either the ordinary burs of the dental engine or, what is preferable, a bur with a long shank such as shown in the accompanying illustration (Fig. 695).

Fig. 694



1 2 3

Dr. Younger's reamers.

Fig. 695



1 2 3 4

Engine burs with long shank.

The following are to be recommended: Nos. 1 and 3 of the Walker-Younger trephines, Nos. 1 and 3 of the Younger reamers, Nos. 1 and 2 of the Rollins spiral knives, Nos. 1 and 2 of the Ottofy spiral crib knives, and Nos. 1, 3, and 4 of the Ottolengui reamers and Cryer's osteotome.

During the progress of the drilling of the socket, the tooth should be frequently inserted until a proper adjustment has been secured. Occasionally these teeth can be implanted and so perfectly fitted that it is almost impossible to remove them with the unaided fingers; while at times the bone is so cancellated and the tissues so flabby that a socket, no matter how carefully drilled, will not retain the tooth in place. Nothing is gained by a too close adjustment of the root, as pressure must undoubtedly be exerted, and pressure causes resorption, and may be followed by inflammation. A fair, moderate fitting of the root is all that should be aimed at. Just before the final adjustment the socket, gums, tooth, and all parts contiguous thereto should be placed in an aseptic condition and the cap adjusted in the manner before described. Though the tooth may be adjusted to its socket so that immediately afterward it exhibits much firmness, yet in a few days subsequent to the operation it invariably shows less rigidity and an apparent tendency to loosening. This result is probably due to the resorption of those areas of contact between the tooth and its artificially formed alveolus where the greatest amount of pressure is exerted. The period of loosen-

ing is generally quickly followed by a progressively increasing firmness and immobility of the tooth caused by calcification of the exudate thrown out by the walls of the alveolus in the process of repair of the surgical injury to which it has been subjected by the operation. Planted teeth, when lost, are lost, as a rule, as a result of resorption of their roots. The process seems analogous to the resorption of the roots of deciduous teeth. Present records seem to indicate that resorption of the roots is slowest in progress in replanted teeth; it is more rapid in transplanted teeth, and most rapid in implanted teeth. Intelligent observation over replantations and transplantations extends from twenty to forty years. The observation of implanted cases extends at this writing to about twenty-five years, and successful cases have been under observation which have remained in the mouth over twelve years. The writer has the records of cases which have remained and done good service for the same length of time.

CHAPTER XX

MANAGEMENT OF THE DECIDUOUS TEETH

By CLARK L. GODDARD, A.M., D.D.S.

Eruption.—The first operation the dentist is called upon to perform for the deciduous (temporary) teeth is lancing the gums as an aid to eruption of those organs. This is not necessary in normal but only in pathological cases. Although gum tissue in its normal condition is comparatively insensitive, when it is inflamed it is exceedingly tender.

The principal source of pain, however, is not in the tissue overlying, but when a tooth, bound down by the dense gum tissue above it, by the growth of its own root presses upon the formative organ below, it causes pain which in many cases may be so excessive as to cause reflex disorders of alarming character.

Dr. J. W. White[1] says: "The manifestation of functional inharmony from pathological dentition will depend, as in trouble arising from any other disturbing cause, upon the temperament and health of the child, its dietetic management, and its hygienic surroundings. In some cases there is a gradual development of biliary, gastric, enteric, and cerebral complications, a slow but steady loss of vital power, with effort at recuperation and feeble resistance to the undermining influences which gradually but surely wear out the young life.

"In other cases the indications of disturbance of function are manifested primarily in the nervous system; the symptoms are all characteristic of acute derangement and are dangerous from their violence and uncontrollability. High fever, vomiting, choleraic diarrhea, meningitis, convulsions, stupor, and death are the rapidly succeeding phenomena. Between these two phases there is every conceivable grade of symptoms, every imaginable complication."

By many it has been urged, as an objection to lancing the gums, that, in case the tooth does not erupt mmediately, cicatricial tissue is formed over it which will bind the tooth down more rigidily than before. Cicatricial tissue is, however, of a lower degree of organization than normal tissue, and is more easily broken down. Furthermore it has been proved by actual test that teeth erupt more readily and sooner through cicatricial gum tissue after lancing than through the gum tissue in the same mouth over corresponding teeth that has not been lanced.

[1] American System of Dentistry, vol. iii, p. 327.

The indications for interference are not so much local as general—the fretfulness, inability to sleep, and other symptoms mentioned by Dr. White. The gum tissue over the erupting tooth may or may not be highly inflamed, but the absence of such inflammation does not contraindicate lancing. In fact some of the gravest systemic disturbances occur when no local manifestations are evident.

Fig. 696



Gum lancet.

The object is to divide the gum tissue which binds down the tooth and to allow it free egress. The most suitable instrument is shaped like that shown in Fig. 696, and sometimes used for lancing around teeth before extraction. It should be held like a pencil in writing, so that one or more fingers can form a rest and guide.

For operating on the lower jaw the child is best seated in the lap of the operator with the head against his breast. By passing the left arm around the infant's head and inserting the left thumb in its mouth with the fingers under the chin, the lower jaw can be held rigidly while the right hand performs the operation.

For operating on the upper jaw it is best to lay the child upon a pillow across the nurse's lap. The operator takes the head on or between his knees, opens the mouth by inserting one or more fingers of the left hand, and holds the thumb and forefinger on each side of the alveolar ridge, thus preventing injury to contiguous parts during possible struggles of the child.

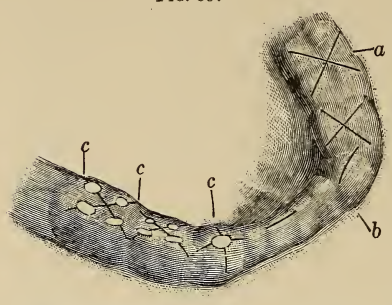
For *incisors* a simple longitudinal incision is made, a little longer than the cutting edge of the tooth. The lancet should be sharp, so as to easily penetrate to the tooth. No harm will be done except to the blade of the lancet. For the *canines* a single incision is good, but a crucial incision is better. Sometimes lancing is necessary for the canine after it is partially erupted, as the gum tissue, pierced by the point only of the tooth, may form a dense ring around this point and interfere with further eruption. In such a case a division of this ring in two or more opposite places will give relief.

For the *molars* a crucial incision is best, one cut extending from the posterior buccal to the anterior lingual cusp, and the next from the posterior lingual to the anterior buccal. Sometimes lancing is necessary for these teeth after partial eruption. After the cusps have pierced the gum, the tooth may be held back by the bands of tissue in the sulci. In such cases division of these bands in the same direction as before described

for an unerupted tooth will give relief. Sharp-pointed curved scissors are well adapted to this latter operation.

Fig. 697 will illustrate the direction of the incisions described. The relief afforded is generally immediate. In one case a child who had been fretful for several days, and who had not slept at all during the day, was asleep in the writer's arms within five minutes after the operation. The gum tissue is not very sensitive, so the operation is often painless. The little sufferer will often recognize the relief obtained and point to other portions of the gums for further relief.

FIG. 697



Lines of incision in lancing: *a*, *a*, over the molars; *b*, *b*, over the canines and incisors before eruption; *c*, *c*, *c*, over the molars and canines after partial eruption. (J. W. White.)

Duration of the Deciduous Teeth.—The importance of filling cavities in the children's temporary teeth is often overlooked, even by dentists themselves, as these teeth are supposed to be lost so early as to render such operations unnecessary. This is generally true with the incisors, is less true with the canines, while the molars often need attention. Fig. 634 (see Chapter XVIII) shows the relations of the deciduous to the permanent dentures in a child of about six years of age. A study of the following table will show that while the incisors are superseded early by their successors the molars are in place nearly twice as long:

Time of eruption.		Loss.	Duration.
Central incisors	6 to 8 months.	6th to 7th year.	$5\frac{1}{2}$ to $6\frac{1}{2}$ years.
Lateral	7 to 9 months.	7th to 8th year.	$5\frac{1}{2}$ to $6\frac{1}{2}$ years.
First molars (1 yr. 2 mo. to 1 yr. 4 mo.)	14 to 16 months.	9th to 10th year.	$7\frac{1}{2}$ to 9 years.
Canines ($1\frac{1}{2}$ yrs.)	17 to 18 months.	Inf. 8th to 10th year. Sup. 11th to 12th year.	7 to 10 years.
Second molars ($1\frac{1}{2}$ yrs. to 2 yrs.)	18 to 24 months.	12th to 13th year.	10 to 11 years.

The temporary molars should be preserved for three reasons:

1. To prevent the child suffering pain.
2. To allow proper mastication of food.

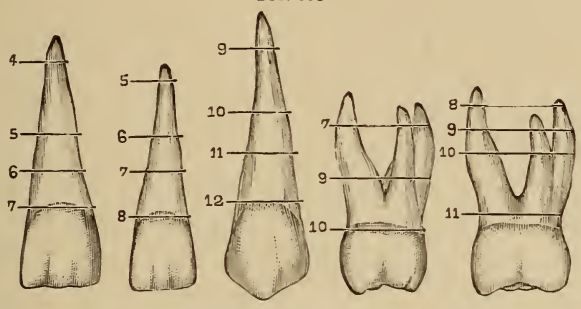
This latter is of extreme importance, as these years are especially important ones in the child's growth. If he is prevented by pain from properly masticating his food it will not be assimilated, and a habit of swallowing food without masticating may be continued even when the permanent teeth have erupted.

3. To preserve the fulness of the arch for the permanent teeth and assure the correct positioning of the first permanent molar, upon which depends much of the regularity of the permanent denture.

Early loss of the deciduous second molar will allow the first permanent molar to move forward and occupy room that should be preserved for the premolars (bicuspids). Early loss of the first temporary molar will allow the second temporary and the first permanent molar to move forward.

The crowns of the temporary molars are much larger than the necks, and caries of the proximal surfaces will allow them to crowd together with the same result. Proximal fillings inserted should be so shaped as to preserve the original contour. If the first permanent molar thus moves forward of its natural position a smaller arch is left for the successional teeth. The result may be a constricted arch, a pointed arch, upper protrusion, or the labial displacement of the canines.

FIG. 698[1]



Decalcification of the deciduous teeth. The numbers indicate years.

THE CHARACTER OF THE PATIENT

The conditions of operating on the deciduous teeth vary so much from those pertaining to the permanent teeth that a different consideration must be taken of filling materials.

The little patients' mouths are small. They are often too young to reason with or to understand the purpose of the operation. They have been too often frightened by thoughtless remarks of their elders in speaking of their dentist.

Oftentimes the first sitting must be utilized merely to make the acquaintance of the child, perhaps cleaning the teeth a little, or introducing some palliative dressing in an aching tooth. The greatest care should be taken not to hurt the child. After it has gained a little experience it recognizes the benefit of the treatment, and will often submit to operations that older patients even shrink from.

Odontalgia.—The first visits by children are usually for the relief of "toothache," and may occur at any age from two years upward.

[1] Prof. Pierce in American System of Dentistry, vol. iii, p. 639.

The first treatment of most children's teeth should be palliative. In many cases a fear of the dentist has been engendered, which it should be the prime object to remove. Make the acquaintance of the little patient in the reception room, talking perhaps of things altogether foreign to the case in hand, and distract its attention. If the child is very timid, examine the teeth while it is seated in an ordinary chair, or in its parent's lap, and apply some dressing to relieve the pain.

In the operating room the chair should be adjusted to its smallest size; a special child's seat may be used, or a cushion half the size of the chair seat, and not too soft. The child's head should be made comfortable in the head-rest. The operator should not let the child detect him in an endeavor to hide instruments; the necessary ones may be shown to him if they arouse his curiosity, and their purpose explained.

On account of the difficulty the child has in making himself understood, or from his not knowing what he wishes to describe, diagnosis is difficult. A child cannot always distinguish just where pain is felt, nor always remember its exact location. In most cases the first occurrence of pain is during mastication.

It is necessary to ascertain whether pain is caused by an erupting tooth, a nearly exposed pulp, a pulp inflamed and dying, a putrescent pulp, or an alveolar abscess. If the nearly exposed pulp is suspected, test it by the application of a drop of cold water. Pain during mastication may be caused by thermal changes, by pressure of food in the cavity, or by pressure on a tooth whose pericementum is inflamed.

If the tooth is aching while the child is in the chair, syringe out the cavity with warm water, dry it with bibulous paper, and apply a pledget of cotton saturated with oil of cloves, campho-phénique, or whatever has been found effective with permanent teeth. Fletcher's carbolized resin[1] has been invaluable for this purpose in the writer's practice. Applied on a pellet of cotton it acts as an anodyne, and the resin hardens in the cotton, forming with it a temporary stopping which will even bear the force of mastication for a few days. It is sometimes best to renew this dressing a few times before attempting a more permanent treatment or filling.

If the child cannot be brought to the office again within a few days, let the parent provide himself with a bottle of the carbolized resin and an inexpensive pair of dressing pliers. Instruct the patient how to apply the cotton dressing. This is the best domestic remedy for odontalgia. Other medicaments may be used by the parent, such as oil of cloves, campho-phénique, etc., but their effect is much more temporary. A more durable dressing may be made by mixing zinc oxid and carbolized resin to the consistence of putty and applying it in the cavity

[1] Carbolic acid,
Resin (colophony) āā ℥j
Chloroform f℥ss

previously dried. It hardens under moisture, and makes a stopping that will remain, in some cases, for several weeks.

During such palliative treatment, sometimes unavoidably extended over several weeks or even months, the child is growing older, is gaining experience, is becoming used to manipulation, begins to recognize the benefit of treatment of the teeth—in a word, is being trained or educated for a good patient for whom more permanent operations may be attempted.

Prof. L. L. Dunbar says: "As a domestic palliative always at hand, in the treatment of pulp exposure and restricting odontalgia, use ammonia on cotton; its repeated use will devitalize the pulp, at the same time effecting its removal by saponification."

TREATMENT WITH SILVER NITRATE

More than forty years ago the application of silver nitrate for arresting decay was advocated, but for many years no notice was taken of it. Within the last five years it has been advocated again, especially for use in the temporary teeth. The fact that it blackens the decayed surface is not as objectionable as with permanent teeth. Dr. Stebbins[1] advocated the use of a solution of the crystals of silver nitrate in carious cavities in temporary teeth. He applies it by means of a small stick inserted in a socket instrument as shown in Fig. 699. Many

FIG. 699



cases will need no further treatment, decay being completely arrested. Some cases will need secondary treatment after a few months. In many cases he advises filling the cavity with gutta-percha after the application.

Dr. C. N. Peirce[2] advises saturating pieces of blotting paper with 40 per cent. solution of silver nitrate, and keeping these on hand for use.

Dr. E. C. Kirk advises the use of asbestos felt for saturation with the solution in preference to blotting paper or cotton. He says:[3] "The contact of silver nitrate with vegetable fiber of any sort involves not only a destruction of the fiber, but also of the silver nitrate, so that the

[1] International Dental Journal, 1891, p. 661.
[2] Ibid., 1893, p. 152.
[3] Dental Cosmos, 1893, p. 667.

preparation in a short time loses its desirable qualities." He advises that the asbestos felt be heated before the blowpipe before saturation, to burn out any organic material which may be present.

Dr. A. M. Holmes[1] advises its use as follows for proximal cavities: "Cut away the walls to a V shape, and with a piece of gutta-percha, softened by heat, of the proper size to fill the space, bring the surface to come in contact with the diseased part of the teeth, into contact with the powdered crystals of silver nitrate and carry it to the place in the tooth or teeth prepared for its reception, packing it firmly and leaving it there to be worn away by use in mastication. When that takes place the surfaces of the teeth treated will be found black and hard, with no sensitiveness to the touch or to change of temperature, and they will remain so indefinitely. In case the child is so timid as to prevent this course, dry the cavity, take out as much softened dentin as the patient will permit, carry the crystals on softened gutta-percha into the cavity and pack it, leaving it until such time as desirable to make a more thorough operation."

In the writer's opinion it is better to open proximal cavities from the occlusal surface rather than make V-shaped spaces, as the full diameter of the teeth should be left to preserve the fulness of the arch.

Silver nitrate in its action penetrates but a short distance.

FILLING MATERIALS

Gutta-percha.—Pink base-plate gutta-percha is a most valuable filling material. In proximal cavities where it is not exposed to wear and where the shape of the cavity is such as to retain it, it is practically indestructible. In occlusal and compound cavities in which it is exposed to wear it has wonderful durability, lasting in some cases for several years.

Directions for Use.—Cut the gutta-percha in small pieces and place them on a gutta-percha warmer, where they can be kept soft but not heated enough to injure the material. The instruments also should be warmed.

Occlusal Cavities.—Cut away the margins of thin enamel with suitably shaped chisels, and remove the decayed and softened dentin with spoon and hatchet excavators. Do this as thoroughly as the patient will permit, but do not sacrifice the patient to thoroughness, for the thorough removal of softened dentin is not as essential with the deciduous as with permanent teeth, because the gutta-percha is, by mastication, kept in such accurate contact with all the walls of the cavity that further softening will go on very slowly if at all. No special

[1] Dental Cosmos, 1892, p. 982.

attention need be paid to the form of the cavity, except that its mouth should not be larger than the interior, nor should any parts of the cavity be inaccessible to the filling material. After excavating, dry the cavity with bibulous paper, and apply campho-phénique, oil of cloves, or carbolic acid, to sterilize any softened dentin which may not have been removed. For drying cavities, prepare paper cylinders, of different sizes, as follows: Tear the bibulous paper in strips from half an inch to two inches in width. Roll or twist each of these strips into a rope, but not too tightly—just enough to retain the shape. Cut these ropes into cylinders from a quarter to half an inch in length. Some of these will be as large around as a lead pencil and others no larger than the lead itself.

Protect the tooth from moisture as well as possible. For lower cavities fold a small napkin diagonally from the corner until it is about half an inch wide. Put the end of this between the gum of the upper canine and the lip and extend the napkin back between the upper molars and the cheek beyond the last tooth, then down behind the last lower molar, and press it between the lower teeth and tongue. Tell the patient to raise the tongue as it is applied, then to lower the tongue and hold the napkin with it. The part of the napkin between the upper teeth and the cheek will cover the mouth of the duct of Steno, and prevent or absorb the flow of saliva. It is better to cover the mouth of this duct with a piece of spunk about half an inch in diameter before applying the napkin. The folds of napkin between the lower teeth and tongue and under the tongue will absorb the saliva from the submaxillary glands. This part of the napkin can be held in place with a mouth mirror or other blunt instrument, by the operator or assistant. After applying the napkin use a large bibulous paper cylinder to absorb the moisture from the tooth to be filled and also from contiguous ones. With smaller cylinders or pellets dry the cavity. Apply once more campho-phénique or other medicament, and absorb the excess.

The gutta-percha having been meanwhile warmed and softened, pick up a small piece of it with a cold round-pointed instrument and press it into the cavity. If the cavity is not large, a single piece of gutta-percha of a diameter less than that of the cavity, but longer than the cavity is deep, can be pressed in quickly and at one movement. For medium-sized cavities select a piece of gutta-percha large enough to cover the floor of the cavity and press it into place with a cold instrument, as a warm instrument might drag it from its place. Add similar pieces, pressing each one to the place in which it is to remain, until the cavity is full. If at any time the gutta-percha in the cavity becomes so hard as to lose its plasticity, apply a warm instrument to soften the surface, so that the next piece will adhere to the others. As the filling nears completion select a small piece for the last, just

large enough to complete the filling and no more, so that none will have to be trimmed away, for in trimming the surplus away the filling may be drawn from contact with the walls of the cavity.

In filling large cavities it may be necessary to hold the first piece in position with another instrument until sufficient material is added for self-retention. At the completion of the filling slight pressure with a warm instrument should be made in such a manner as to force the material against all the margins of the cavity.

Proximal Cavities.—Where possible, proximal cavities should be opened from the buccal surfaces, as advised by Dr. Bonwill, as in such cases gutta-percha fillings will not be exposed to the force of mastication. This plan is not often practicable because the patient is seldom presented till the cavity has become visible by opening into the occlusal surface of the tooth. In such cases cut away the enamel only enough to give access to the cavity, excavate the decayed dentin, and trim the buccal, lingual, and cervical walls until a smooth, firm margin is obtained.

In filling such a cavity use small pieces of softened gutta-percha, pressing each piece where it is to remain, and avoid a surplus. Press the gutta-percha against the adjoining tooth as if it were a matrix or a fourth wall of the cavity and let it remain. It is useless to trim it away from the adjoining tooth, because the force of mastication would soon spread the filling against it again.

If a proximal cavity cannot be readily shaped so that it will retain the gutta-percha, it may be packed against the adjoining tooth, as if it were an occlusal cavity. It will prevent decay, especially if silver nitrate is applied, as already described, and may be retained until the patient is older, when a more thorough operation may be performed.

The spreading of the gutta-percha by the force of mastication will tend to separate the teeth—which is sometimes an advantage; and also to press upon the gum in the interproximal space—which is a disadvantage. In filling children's teeth we cannot always reach the ideal, but must select the method and material which will have the greatest advantage with the least disadvantage. If the teeth separate so much that the pressure of the gutta-percha upon the gum tissue becomes a serious annoyance, some other material must be substituted.

To prevent the impinging of the gutta-percha upon the gum in the interproximal space, Dr. M. W. Hollingsworth[1] has invented a space guard, consisting of a concave elliptical piece of metal coated on the convex surface with gutta-percha. This guard is to bridge over the interproximal space. It is placed in position with the instrument shown in *b*, Fig. 700, which is warmed slightly, so that the point can enter a small hole in the guard and adhere to the gutta-percha on the

[1] Dental Cosmos, 1896, vol. xxxviii, p. 553.

under side, as shown at *c*. The guard is placed in the cavities, after warming the gutta-percha, as shown in Fig. 701, and thus covers the cervical borders. Gutta-percha is now filled in over the guard as if the two cavities formed a single crown cavity.

Fig. 700

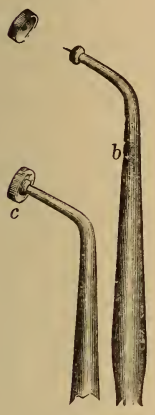
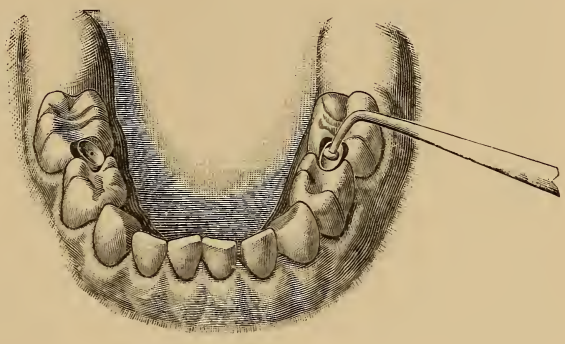


Fig. 701



Advantages of Gutta-percha.—It is easily applied to the cavity; it is insoluble; is durable even when masticated upon; is a non-conductor of thermal impulses; the filling is finished as soon as the cavity is full; it spreads under the force of mastication, and is thus kept in contact with the walls of a cavity; it can be used even under moisture.

Disadvantages.—Gutta-percha is softer than other filling materials, and hence wears away more rapidly. In proximal cavities it will spread the teeth apart, and may then press upon and irritate the gum.

Dryness of the cavity, though very desirable, is not absolutely necessary.

Advantage of Zinc Phosphate Cement.—It is a poor conductor of heat; it withstands the force of mastication better than gutta-percha; it adheres to the walls of the cavity, and hence will remain where no other material can; it is easily applied; its color may be selected to match the tooth.

Ames' copper cement seems to be even a better preservative than zinc cements in places where the black color is not objectionable.

Disadvantages.—Absolute dryness of the cavity is a prerequisite to its success; it must be kept dry for several minutes after it is inserted in the cavity. Zinc phosphate cement disintegrates in some mouths much more rapidly than in others. If placed too near the pulp it may by chemical irritation devitalize it.

Application of the Rubber Dam.—While many hesitate to attempt the use of the rubber dam with children, it will be found upon trial that most of them will submit to it without trouble, and many will prefer it to other means of keeping cavities dry.

Although there is an advantage in applying the rubber dam before excavating—because dryness makes the teeth less sensitive, and a clearer view of the cavity is obtained—still, for the sake of not tiring the little patients by too long restraint in one position, it is better to do most of the excavating before its application.

The small size of the necks of the deciduous teeth compared with that of the crowns renders the retention of the rubber dam easier than with permanent teeth. Even considering the smallness of the patients' mouths, the application of the rubber dam is not difficult in many cases.

For retaining the rubber dam on the second molar a clamp will sometimes be necessary, but for the other deciduous teeth a floss silk ligature will be sufficient. Having punched holes of suitable size through the rubber dam, apply it over the teeth affected. If the cavity is in the occlusal or buccal surface only, it will not be necessary to apply it over more than one tooth; but if the cavity is in the proximal surface it will be necessary to apply the rubber dam over two or sometimes three teeth, or even more, if several cavities are to be filled at one sitting.

It is not always necessary to tie a ligature around the neck of the tooth, as merely passing the waxed floss silk between the teeth will often force the rubber around the neck of the tooth enough to retain it even above a proximal cavity. The silk may then be removed by drawing the end through between the teeth.

With a thin burnisher or spatula turn up the edge of the rubber around the neck of the tooth toward the gum. The tendency of the rubber then will be to slide in that direction and not over the crown. If a ligature be necessary to hold the rubber above the edge of a proximal cavity tie it tightly around the neck of the tooth, even forcing it toward or under the edge of the gum with an instrument when necessary. The clamp on a second molar may often be dispensed with after a ligature is applied, unless it is needed to hold the rubber out of the operator's way. The only object in omitting the clamp is to prevent pain or discomfort to the child.

If a simple ligature will not retain the rubber on a second molar before the first permanent molar has appeared, its efficiency may be greatly increased by stringing a bead, about an eighth of an inch or less in diameter, on the thread and tying a simple knot in it so that the bead will be in about the middle of the ligature. Tie the ligature around the tooth so that the bead will lie against the distal surface of the second molar on or near the gum. This bead will prevent the rubber slipping off the tooth. A short cylinder of bibulous paper may be tied in the ligature and applied with the same effect, and even a large knot in the ligature on the distal surface of the tooth will often answer the purpose.

The corners of the rubber dam should be held out of the way by a suitable holder extending around the head. The lower border may be held out of the operator's way by small weights, hooked in the edge.

Dry the cavity and the whole tooth or teeth, and complete the excavation.

Filling Cavities and Cement.—As cement can be applied easily in undercuts and very irregularly shaped cavities it is not necessary to cut away the enamel more than is sufficient to enable the operator to remove the disintegrated dentin thoroughly. Even the thorough removal of the latter is not as essential for a cement filling as for other materials, for, if the edge of the cavity can be made smooth and the softened dentin be thoroughly sterilized, the cement will hermetically seal it and prevent further disintegration until it is worn away beyond the sound edges.

It must be remembered in excavating cavities in deciduous teeth that the pulp is much larger in proportion to the size of the crown than in permanent teeth, and that in trying to make undercuts or retaining grooves deep enough to retain a filling, the pulp may be exposed—an accident which should be carefully guarded against, for the deciduous pulp has not the recuperative power possessed by the pulp of a permanent tooth. Moreover, death of the pulp prevents normal resorption of the root, and may thus cause irregularity of the permanent teeth.

For most cases the cement should be mixed as thick as can be easily and quickly manipulated, but if the pulp is nearly exposed the cement should be used so thin that it can be applied without pressure, by flowing it over the floor of the cavity. Cement mixed moderately thin will adhere better to the walls of the cavity than when it is as thick as it is possible to apply it. The thinner the cement the longer time it will take to harden, but the thicker it is mixed the more durable it will be. Do not keep the little patient in a constrained position longer than necessary. The easier the first operation is for him the more readily will he return for the second.

If the pulp is very nearly exposed apply Fletcher's carbolized resin over the floor of the cavity. For this purpose remove the stopper of the bottle until by evaporation the carbolized resin has thickened to the consistence of syrup. Dip a small probe in the thickened mass, so that a small drop will adhere to the end. This drop may be then conveyed to and spread over the floor of the cavity. This will prevent contact of the cement with the most sensitive dentin and lessen the possibility of deleterious action on the pulp.

Where it is possible to apply the rubber dam and to excavate thoroughly the same excellent result with cement may be expected as when it is used in permanent teeth, but often it is not possible to operate as thoroughly.

By applying *melted paraffin*[1] or *sandarac varnish* to the cement the rubber dam may be removed sooner than otherwise, and the cement will be protected from moisture by the coating of paraffin or varnish.

As paraffin is insoluble in any agent that can attack it in the mouth, the more it is absorbed by the cement the longer it will protect it from everything but wear; therefore, do not be content merely to flow the melted paraffin over the cement, but hold a heated instrument in contact with the filling and keep the paraffin melted until all that is possible is absorbed. If a proximal filling has been inserted pass a very thin heated spatula between the cement filling and the adjoining tooth to make sure that the paraffin covers it to its cervical margin.

When the rubber dam cannot be applied, cement may still be used with success if the cavity can be kept dry with napkins or rolls of cotton or spunk until it is inserted and quickly covered with melted paraffin.

Deep cavities may be advantageously lined with cement and protected with paraffin until the cement is hard, when the paraffin may be removed and gutta-percha or amalgam inserted.

Occlusal fillings of cement can be kept dry by applying temporary stopping very soft as soon as the cement is put in. Gilbert's is excellent for the purpose, as it adheres to the cement. Buccal fillings, sometimes approximal, may be protected in the same way. A thin temporary stopping may be left to be worn away by occluding teeth.

Cavities in Incisors.—Decay in deciduous incisors is much more rare than in the other teeth, and they are lost so early in child life that it is seldom necessary to fill them. Zinc phosphate cement is the best filling material for these teeth, because they are so small that it is very difficult to shape the cavities properly for retaining other materials.

If it is found that cement disintegrates rapidly in proximal cavities, an attempt should be made to shape them so as to retain gutta-percha. The first filling of cement may have removed the sensitiveness sufficiently to allow deeper excavating at a subsequent sitting, or there may have been a deposit of secondary dentin, thus removing the pulp from danger of exposure in properly shaping the cavity.

Amalgam.—While amalgam is a valuable filling material, its use necessitates much greater care in the preparation of cavities than is necessary with gutta-percha or cement, for it neither spreads under mastication like the former nor does it adhere to the walls of a cavity like the latter. The spreading of gutta-percha will stop a leak that would be fatal to an amalgam filling, and cement will adhere in a cavity from which amalgam would be easily dislodged.

Amalgam should be used when the decay can be thoroughly excavated and the cavity prepared with strong, smooth edges, and good, retaining form. As amalgam is a better conductor of thermal im-

[1] Dr. Bonwill's suggestion.

pulses than either of the materials before mentioned, it will not be tolerated so near the pulp, hence deep cavities must be lined with either gutta-percha or zinc phosphate.

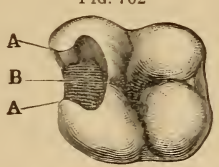
The large size of the pulp of deciduous teeth—greater in proportion than that of the permanent teeth—must not be forgotten in excavating, and often it is impossible to make suitable retaining grooves for amalgam without cutting dangerously near the pulp, especially in proximal cavities.

The preparation of occlusal cavities is comparatively simple, as the enamel may be easily cut away so as to make firm edges, slightly bevelled, and to allow thorough excavation of softened dentin.

The burring engine can be used to greater advantage with children than many would suppose. The whirring noise often distracts their attention from a slight pain they might otherwise notice, and the assurance that the work can be done more quickly is a great encouragement.

In preparing proximal cavities for amalgam a free opening should be made in the occlusal surface and given a dovetail shape, extending farther upon the occlusal surface in proportion to the size of the cavity than in permanent teeth, because more reliance must be placed on it for retention than upon lateral grooves, for there is not much depth of dentin in which to make them. The cervical border of the cavity must be smooth and the floor at right angles to the long axis of the tooth. The lateral walls must be cut smooth and bevelled, and may be slightly grooved. If the cavity extend below the margin of the gum, the latter should be crowded away with a temporary stopping or by packing a tightly rolled pledget of cotton between the teeth and relying on its swelling.

FIG. 702



Prepared cavity showing bevelling of enamel edges, *A*,*A*, and square base for filling, *B*.

In many cases it is possible to extend a proximal cavity to the sulcus and make a step anchorage, as in permanent teeth.

While the application of a rubber dam is not as essential as in using cement, it is a great advantage, for it renders the proper preparation of the cavity more certain, but it need not be applied until the cavity is nearly prepared. Its use is more often necessary with the lower teeth than with the upper.

Amalgam should not be mixed too dry, but should be plastic enough to be packed easily without crumbling. In occlusal cavities introduce a piece half as large as the cavity, and with a small ball burnisher spread it over the floor of the cavity toward the walls. Introduce other smaller pieces and proceed as before until the cavity is nearly full. Excess of mercury is thus forced to the edges of the cavity, whence it can be brushed away with cotton or bibulous paper.

The last pieces of amalgam should be "wafered," as recommended by Prof. J. Foster Flagg—that is, squeezed in chamois skin with large

flat-nosed pliers until as much mercury as possible is pressed out. This leaves the amalgam in a thin, brittle wafer, too hard for ordinary use. Break it up in pieces half the diameter of the cavity. Press one of these in the middle of the nearly completed filling. It will readily absorb the excess of mercury that has been worked to the surface, and can be spread toward the margins with a round burnisher. Other pieces can be burnished on until the filling is quite hard.

In filling proximal cavities the same plan may be followed if a matrix of thin steel or German silver be used. In lieu of the matrix a very thin spatula may be held between the teeth.

Whenever possible, fillings in deciduous molars should be given full contour to prevent the crowding of food between the teeth and also to prevent the first permanent molar from crowding them together and thus taking up room which will be needed by the bicuspids.

The child should be cautioned against masticating too soon upon proximal fillings, although no caution is needed in case of occlusal fillings hardened by the "wafering" process.

Tin and gold are excluded from the list of desirable filling materials for temporary teeth, not because they are not good filling materials, but because the circumstances are such that they cannot be used to advantage. Although a small gold filling may be inserted in a few minutes in an occlusal cavity, the insertion of a large gold filling would be inflicting a needless cruelty on a child on account of the length of time it must be held in one position.

As the insertion of a tin filling is nearly if not quite as difficult and tedious an operation, it is open to the same objection.

EXPOSED PULPS

On account of the difficulty of properly capping an exposed pulp in a deciduous tooth, the operation should seldom be attempted. It is better to devitalize the pulp and remove it.

Extirpation of the pulp may ordinarily be accomplished painlessly after anesthetizing it with cocain under pressure.

If, however, for any reason, immediate extirpation under cocain anesthesia becomes impracticable in a given case, then resort may be had to the use of arsenous oxid paste as a devitalizing agent, always having in mind that but a minute quantity of the paste is required and less time is needed to effect the devitalization of a deciduous tooth pulp than that of a permanent tooth. Any of the numerous arsenical pulp-devitalizing pastes may be used in children's teeth under reasonable restrictions as to quantity of the drug used and length of time of the application.

The writer has found the following formula[1] an excellent one:

℞—Acidi arseniosi,
Morphiæ acetatis,
Pulv. opii āā equal parts
Creosoti q. s. to make paste.

Why opium and acetate of morphine should both be used in the same prescription is not clear, as their properties are so nearly the same, but the paste has been satisfactory in devitalizing pulps with no pain, or with a minimum amount. Other formulæ may be equally satisfactory.

In *occlusal cavities* its application is simple. Excavate the softened dentin as thoroughly as possible without inflicting pain, using spoon-shaped excavators to prevent puncturing the pulp. If the excavation can be carried far enough to apply the paste directly to the pulp its action will be more rapid. Dry the cavity, apply a small amount, not larger than half a pinhead in size, with a small probe and cover it with a pellet of cotton, or place in the cavity a small pellet of cotton one side of which has been touched to the paste. Add enough pellets of dry cotton to fill the cavity, then apply a drop of sandarac varnish, sufficient to saturate at least half the depth of cotton. This is a better plan than dipping the pellets in the varnish before inserting, because an excess of the latter is apt to come in contact with the pulp and cause pain, or, penetrating between the paste and the pulp, may render the former inoperative. Temporary stoppings, such as Gilbert's, White's, or Fowler's, are excellent for sealing the cavity, but take a little more time than cotton and varnish. Such temporary stopping should be well softened by heat to prevent pressure on the pulp in its insertion. A good plan is to warm the end of the long stick of stopping and press it into the cavity, using the remainder of the stick as a handle, then remove the surplus and smooth with a warm instrument.

In *proximal cavities* extending near to or under the margin, the gum should be protected, before applying the paste, as follows:

Make, by rolling between the fingers, a cylinder of cotton as long as the width of the tooth and about the size of the lead of a pencil. Saturate it with sandarac varnish and pack it between the teeth upon the gum, extending part of it below the edge of the cavity, thus sealing this portion of the cavity and reducing it nearly to the form of an occlusal cavity. Paste applied in a proximal cavity so protected cannot flow upon the gum unless too great a quantity has been used. The paste should be applied and sealed as in an occlusal cavity.

"Devitalizing fiber" is very satisfactory and may be used with less fear of its affecting the gum tissue.

The paste may be allowed to remain in the cavity for from twelve to forty-eight hours. The possibility of the dressing being dislodged, so

[1] Used by Dr. E. N. Clarke in the "fifties."

as to allow the paste to come in contact with the gum tissue, should warn one to have the patient return much sooner than when the case is an occlusal cavity from which it is impossible for the paste to escape.

Much has been said about the danger of application of arsenic in deciduous teeth when the roots are undergoing resorption, but the writer has never seen any bad effects from such use; still it must be admitted that the ratio of danger varies with the degree of resorption of the root. An examination of Prof. Peirce's diagram (Fig. 698) will show the average amount of resorption at different ages, and enable one to discriminate. The writer believes that the sensitiveness of a deciduous pulp varies inversely with the amount of resorption of the root, and that devitalization is called for in very few cases in which there is danger of deleterious action.

Prof. L. L. Dunbar advises the use of aqua ammoniæ for devitalizing the pulp of a temporary tooth, by applying it on a pledget of cotton in the cavity, one or two applications being sufficient in most cases. This plan is not open to the objections urged against the use of arsenous oxid.

When the pulp is devitalized, open the cavity freely into the pulp chamber and apply on cotton glycerite of tannic acid. Leave this about a week, by which time the pulp tissue will have become so hardened by the tannin that it may be removed much more readily than without such treatment.

The application of mummifying paste is advised by many, after devitalization, to avoid the necessity of removing the pulp. If a real mummifying paste can be found, its application will be the ideal treatment, but experience has demonstrated that the use of those thus far proposed is less satisfactory than the practice of radical removal of the pulp tissue and obliteration of the chamber and canals by a suitable filling material.

FILLING PULP CANALS

In the pulp canals apply iodoform paste made by mixing iodoform with oil of cassia and glycerol to such a consistence that it can be readily applied on a probe.

Fill the pulp chamber with "temporary stopping" or gutta-percha, and the cavity with cement, gutta-percha, or amalgam, according to indications.

If the tooth be very frail, fill the cavity with cement, because, owing to its adhesive properties, it strengthens the tooth. If the cavity be proximal and it is desirable to wedge the teeth apart, use pink gutta-percha.

If the walls be strong and some time will elapse before the natural exfoliation of the tooth will occur, fill with amalgam.

If absorption of the roots occurs, the iodoform in the canals will not interfere.

Salol, which was advocated as a root filling for permanent teeth by Dr. A. E. Mascort,[1] of Paris, France, is well adapted also for filling the canals of deciduous teeth. "It is a white crystalline powder, insoluble in water and glycerol, but soluble in alcohol, ether, chloroform, etc.; fuses at 40° C., but crystallizes quickly again." Melted together, salol and aristol, salol and iodoform, or salol and paraffin, become liquid like salol alone. After a pulp canal is thoroughly dried the salol may be fused on a small spatula and carried to the canal, into which it will be taken by capillary attraction, or a broach may be heated and inserted in the salol. A small quantity will adhere like a drop of liquid and may thus be carried to the canal. The heated broach may be again introduced in the canal to insure thorough application. Dr. Mascort uses the hypodermic syringe with a small needle for introducing into the canals. It will crystallize in a very short time, making a solid filling.

ALVEOLAR ABSCESS

The treatment, as with the permanent teeth, consists in removal of the cause, *i. e.*, almost invariably, a decomposed pulp. Even here an abscess seldom occurs if there be any opening from the cavity of decay to the pulp chamber, unless a foreign substance has stopped this opening.

Make a free opening into the pulp chamber and with a syringe wash out as much of the contents as possible. Dry the chamber and apply a dressing of formo-cresol (Buckley) or formo-phenol, the former consisting of equal parts formalin and tricresol, the latter of equal parts phenol and formalin. The dressing should be sealed in with a porous dressing seal, such as cotton saturated with carbolized resin or a thick solution of aristol in chloroform and the case dismissed until all inflammatory symptoms have subsided, when the roots may be filled with iodoform paste and a permanent filling inserted in the carious cavity.

If a fistulous opening has formed through the outer alveolar plate, but not through the gum, an opening should be made through the latter with a sharp lancet about five minutes after the application of 4 per cent. cocain hydrochlorid solution on a wad of cotton.

If a mild antiseptic solution such as electrozone or 1 per cent. potassium permanganate can be forced from the pulp chamber through the root canals and fistulous opening, the accumulated pus will be thoroughly evacuated and the cure hastened. As a rule, however, the abscess disappears after the cause is removed, that is, the putrescent or decomposed contents of the pulp chamber and canals.

After drying the pulp chamber and canals, apply iodoform paste therein and seal the cavity for a few days with temporary stopping.

[1] Dental Cosmos, 1894, p. 352.

When the inflammation of the pericementum has disappeared the pulp chamber and canals may be filled as before directed.

Often the inflammation of the pericementum will be so great, or in popular expression the tooth so "sore" to the touch, when the case is presented that at the first sitting nothing more can be done than to make an opening into the pulp chamber to allow the escape of pus or gases of decomposition. This relieves the pain, and manipulation and treatment may be left until the inflammation has subsided.

PROPHYLACTIC TREATMENT

This lies more in the hands of the parent than of the practitioner, but should be strongly urged by the latter upon the former. The nurse or parent should begin early to clean the child's teeth by means of a cloth wrapped around the finger. If the teeth cannot be kept clean in this manner a small brush should be used, especially after eruption of the molars. Floss silk should be used daily between the teeth. One end of the silk should be held in each hand so as to pass over the end of each index finger and be made taut between them. This taut part can be pressed down between the teeth and passed up and down against the proximal surface of each tooth, then one end of the thread should be released and pulled through the interdental space.

This will drag out any particles of food that may be there, and is much better than the toothpick for the purpose. If particles of meat or other food have lodged so firmly that the plain waxed silk will not dislodge them, tie a single knot in the thread and pull that through.

This cleansing with the cloth, brush, and silk should be done before the child retires at night, for that is the "period of decay." The parts are at rest longer than at any other time, and the fluids of the mouth are not kept in circulation between the teeth by means of the tongue, lips, and cheeks. Theoretically the teeth should be thus thoroughly cleaned after each meal, but "satiety breeds disgust," and it is not best to insist on more than will probably be accomplished.

Children will soon learn to use the brush and floss silk themselves, and finding the mouth much more comfortable when "clean," they will endeavor to keep it so. Many a child has been denied candy for years from the belief that "sweets decay the teeth," but parents may be assured that no harm will be done by the moderate use of pure candy if the "sweet" is not allowed to remain between and around the teeth until it becomes acid, and that may be prevented by cleansing the teeth after the candy or sugar is eaten. A child may be taught cleanliness in this manner who would be only taught rebellion by the repeated denial of sweets, the reasons of which he cannot understand.

Prophylactic mouth washes should be used—such as Listerine diluted to a 10 per cent. solution.

CHAPTER XXI

ORTHODONTIA

By EDWARD H. ANGLE, M.D., D.D.S.

OCCLUSION

"Substantial progress in any science is impossible in the absence of a working hypothesis which is universal in its application to the phenomena pertaining to the subject-matter. Indeed, until such a hypothesis is discovered and formulated, no subject of human investigation can properly be said to be within the domain of the exact sciences. It enables one skilled in the science to practise it with a certainty of results in exact proportion to his knowledge of its principles and skill in applying them to the work in hand."—Hudson.

Orthodontia[1] is the science of occlusion of the teeth and the art of correcting malocclusion.

Occlusion is the basis of the science of orthodontia. The shapes of the cusps, crowns, and roots, and even the very structural material of the teeth and their attachments, are all designed for the purpose of making occlusion the one grand object, in order that they may best serve the chief purpose for which they were intended, namely, the cutting and grinding of food. We will define occlusion as being *the normal relations of the occlusal inclined planes of the teeth when the jaws are closed.*

Malocclusion of the teeth is but the perversion of their normal relations. It can be studied intelligently only from the basis of the normal, and to begin its study without first being familiar with the normal would be as unfruitful as the study of the pathology of any other of the structures of the body without first mastering their anatomy and physiology.

There must be, then, clearly fixed in the mind of the student of orthodontia not only Nature's plan of the normal denture when complete, but also of its beginnings—the growth and development of parts, and their co-relations.

The normal human denture in its completeness includes not only the jaws, alveolar process, dental arches, and especially the teeth and peridental membrane, which to the orthodontist are of prime importance, since on them chiefly his operations are performed, but also the muscles

[1] From the Greek, *ορθός*, straight; *οδόνς*, tooth.

of lips, cheeks, tongue, and mouth, the nasal passages, palate, and throat, as these assist the teeth in performing their functions. They are also powerful factors in establishing and maintaining either harmony or inharmony in the development and arrangement of the teeth, and this just in proportion as they are, singly or collectively, normal or abnormal in their own development and functions.

It is, of course, not within the province of a brief treatise on orthodontia to teach as minutely and thoroughly as is necessary to a complete understanding thereof, the embryology, histology, and anatomy of the human denture. The student is therefore strongly recommended to their study elsewhere, and especially to the works of Drs. Noyes, Black, Broomell, Cryer, and Kyle. A thorough knowledge of the individual teeth is of such inestimable value to the orthodontist that the student is urged to carve, or model in clay, the different tooth forms, as in no other way will there be such a vivid impression stamped upon his mind of the correct outlines of their crowns and the positions and relative proportions of their cusps, together with their marginal, triangular, and oblique ridges, their grooves and sulci, and their proper relations to the teeth of their own arch and to those of the opposing arch.

Nature in building the dental apparatus requires a long period of time—twenty years or more—and from the beginning of the formation of the dental follicle and the tissues that support and precede it, to the eruption of the last third molar, she works in accordance with a definite plan toward a definite end, viz., the production of a type that has been the type of man's denture as long as man has been man.

By referring to Figs. 703 and 704, which represent the teeth in normal occlusion, it will be seen that each dental arch describes a graceful curve, and that the teeth in these arches are so arranged as to be in greatest harmony with their fellows in the same arch, as well as with those in the opposite arch.

In their normal relations the external curve of the lower arch is slightly smaller than that of the upper, so that in occlusion the labial and buccal surfaces of the teeth of the upper jaw slightly overhang those of the lower.

The mesio-buccal cusp of the upper first molar is received in the buccal groove of the lower first molar. The teeth posterior to the first molars engage with their antagonists in a precisely similar way; those anterior to the first molars interlock with one another in the interspaces until the incisors are reached; of these, the upper usually overhang the lower about one third the length of their crowns, although the length of overbite varies according to the typal pattern of the teeth.

The upper central incisor being broader than the lower, it necessarily extends beyond it distally, overlapping in addition about one-half of the lower lateral incisor; the upper lateral occludes with the remaining

Fig. 703



Typical occlusion. (Cryer.)

Fig. 704.



Normal occlusion.

portion of this tooth and with the mesial incline of the lower canine; the mesial incline of the upper canine occludes with the distal incline of the lower canine, the distal incline of the upper occluding with the mesial incline of the buccal cusp of the lower first premolar. In the same order the series of buccal cusps of the premolars occlude—the mesial incline of each upper occluding with the distal incline of the corresponding lower tooth.

The distal incline of the buccal cusp of the second upper premolar occludes with the mesial incline of the mesio-buccal cusp of the lower first molar. The mesial incline of the mesio-buccal cusp of the upper first molar occludes with the distal incline of the mesio-buccal cusp of the lower first molar; the distal incline of the mesio-buccal cusp of the upper

FIG. 705



Normal occlusion.

first molar occludes with the mesial incline of the disto-buccal cusp of the lower first molar; the mesial incline of the disto-buccal cusp of the upper first molar occludes with the distal incline of the disto-buccal cusp of the lower first molar, and the distal incline of the disto-buccal cusp of the upper first molar occludes with the mesial incline of the mesio-buccal cusp of the lower second molar. This same order is continued with the buccal cusps of the second and third upper molars, the distal incline of the disto-buccal cusp of the upper third molar having no occlusion.

It will thus be seen that each of the teeth in both jaws has two antag-

onists or supports in the opposite jaw, except the lower central incisor and upper third molar.

As the inclined planes match and harmonize most perfectly in the bucco-occlusal relations of the teeth, so there is a similar arrangement in their linguo-occlusal relations, except that the lingual cusps of the lower premolars and molars project beyond those of the upper teeth into the oral space, as shown in Fig. 705.

Likewise, in the transverse arrangement, the buccal cusps of the lower molars and premolars rest between the buccal and lingual cusps of the upper molars and premolars, and the lingual cusps of the upper molars and premolars rest between the buccal and lingual cusps of the lower molars and premolars, as in Fig. 706.

FIG. 706



Typical occlusion of molars; transverse view. (Cryer.)

The grinding surfaces are thus enormously increased in extent and efficiency over what would be possible if they consisted of a single row of cusps or of plane surfaces.

But increase of masticating surface is not the only reason for this complex interdigitation of the cusps and inclined planes of the teeth, it is likewise of great importance in providing for the teeth a mutual support.

The sizes, forms, interdigitating surfaces, and positions of the teeth in the arches are such as to give to one another, singly and collectively, the greatest possible support in all directions.

This is the pattern, the form, the type of the normal in occlusion—the normal denture.

In the normal building of the human denture, nature works toward a definite end to produce the most efficient parts with the most efficient arrangement of these parts that they may in function be most efficient. Each tooth is not only in harmonious relation with every other tooth, but helps to maintain every other tooth in these harmonious relations, *for*

the cusps interlock and each inclined occlusal plane serves to prevent each tooth from sliding out of position, and further, to wedge it into position if but slightly malposed, that is, if not beyond the normal influence of the inclined planes.

A careful study of the relations of the inclined occlusal planes and the marginal, triangular, and oblique ridges, in connection with the movements of the jaw, cannot fail to impress thoughtful persons not only with the influence which these exert in maintaining each individual tooth in correct position, but as well their wonderful efficiency for incising and triturating the food required by omnivorous man, and with their marvellous forms and arrangement for self-cleansing and consequent self-preservation. So perfect is the plan in the relations of the teeth as a whole that each cusp or part of a cusp contributes perfectly to the balance, harmony, and efficiency of all, and consequently the mesiodistal diameter of a tooth, or any portion of it, cannot be sacrificed without proportionately disturbing the delicate balance and integrity of form and function of the whole. To one versed in occlusion no argument is needed to impress the importance of the complete and perfect restoration to contour of missing portions of teeth, or of the adjustment to normal position of those teeth that are malposed.

Not only are the individual tooth patterns and the relations of the teeth most perfectly designed for performing their functions, but probably no other forms or relations could produce so beautiful and artistic an effect as an individual feature, or give so much of beauty in lines and expression to the face. The denture, with the teeth in normal occlusion, is a marked element of beauty to any face, however imperfect in other respects.

There is great harmony in the lines of the teeth, although all vary, the result being most pleasing. How the beauty of the central incisor would be impaired if its mesial lines were the same as its distal lines. How much less pleasing would be the result if the lateral incisor were of the same size as the central, or even of the same pattern, instead of possessing the majesty of a pattern and proportionate size of its own. It is like the central, yet how beautiful in its difference. The canine, although resembling both central and lateral, adds much beauty to the whole in the lines peculiar to its own pattern, and how much the general effect is enhanced by the lateral incisor being shorter and slightly less prominent in the line of occlusion than either the central or canine. In orthodontic operations, or in unanatomically fashioned dentures, when the lateral is made prominent or of the same length as the other teeth, the result is pronouncedly unpleasing. Again, how unpleasing is the effect when these beautiful lines are impaired by grinding any of the marginal surfaces—a fact that should lend caution to the hand of both orthodontist and dentist.

Key to Occlusion.—According to nature's plan of the human denture all of the teeth are essential, yet in function and influence some are of greater importance than others, the most important of all being the first permanent molars. They are the largest of the teeth and the firmest in their attachment, which, together with their location in the arches, makes them the most important of all the teeth in the function of mastication. By the lengths of their crowns they also determine the extent of separation of the jaws and length of bite, and in this, as well as in many other ways, are factors in the artistic proportions of the face. Being the first of the permanent teeth to take their positions in the arches, they exercise great control over the positions which the other permanent teeth anterior and posterior to them shall occupy as they erupt at their respective periods and take their respective positions in the arches. As they are already developed and firmly attached in the alveolar process when the other permanent teeth appear, the latter are built into the dental apparatus around them, as it were. They are not only the most constant in the time of taking their positions, but by far the most constant in taking their *normal* positions, especially the upper first molars.

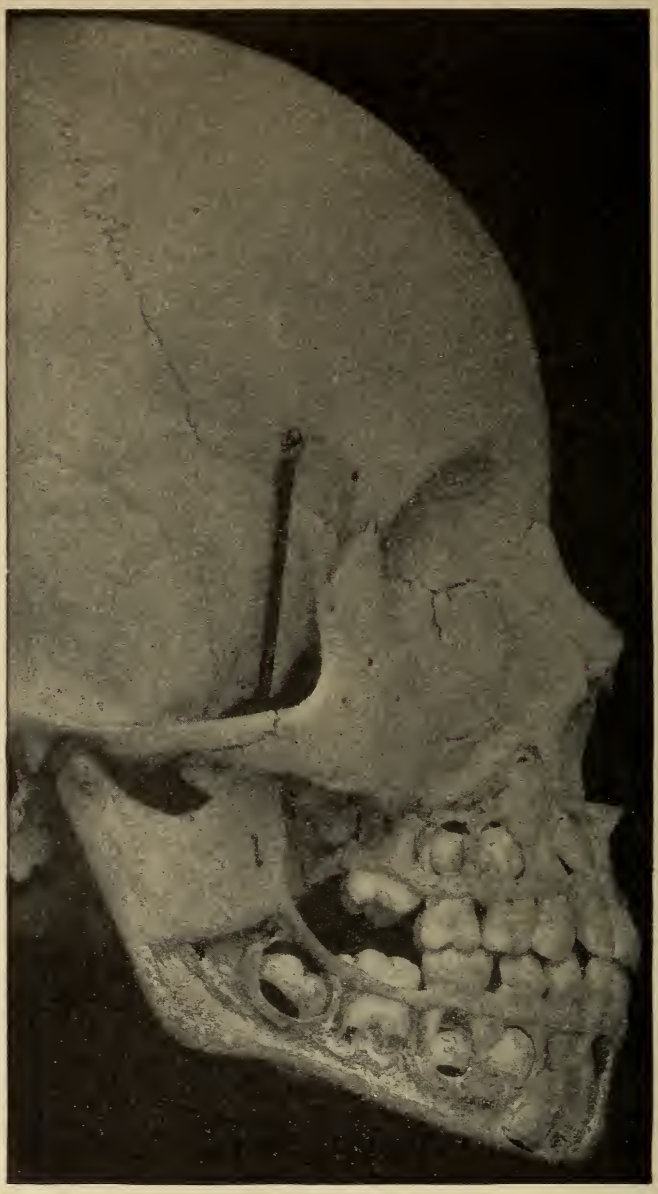
A better understanding of the reason why these teeth take correct positions is gained if we will but remember that theirs are the first permanent tooth germs formed, and also that they are the first of the permanent teeth to develop and erupt, which they do, unhampered, immediately posterior to the twenty teeth comprising the deciduous set, and that the deciduous teeth are free to erupt normally according to nature's plan, under the most favorable conditions, and do so nearly always in normal occlusion and in perfect accordance with the requirements for harmony and beauty of the developing child's face. So the permanent molars in erupting are not only unhampered in taking their positions, but, on the contrary, they are, as it were, guided into and guarded in correct positions by the usually normal child denture anterior to them (Fig. 707), and by their normal locking on eruption is made possible the normal eruption and locking of all the other teeth both anterior and posterior to them in both lateral halves of each arch.

So important is the influence of these teeth in the building of the dental apparatus that we believe nature exercises the greatest care in locating them in the line of occlusion, especially the upper first molars[1]—which we call the keys to occlusion—and so places them that the rest of the dental apparatus may be completed normally, and if completed normally and in harmony with these teeth, the dental apparatus will be in best balance and harmony with the skull and the other essential

[1] Angle, "The Upper First Permanent Molar as a Basis of Diagnosis," Items of Interest, June 1906.

organs, as the eyes, the ears, the nose, etc.—indeed, with the structural type of the individual throughout.

Fig. 707



Normal denture of child.

The fact that the upper first permanent molar varies considerably mesially or distally as to its location in different individuals, which is always noted in anything like an extensive study of the subject, has

led superficial students to regard these positions as abnormal, taken by chance, and often out of harmony with other principles in the anatomy of individuals, but in reality these variations are to be expected, and are necessary in the creation of different types and different individuals. As, for example, this molar is found to be located farther anterior in its relation to the skull in some of the lower orders of man and the primates than in the highly developed civilized man, and even in civilized man the mesio-distal position of this tooth may vary in each individual, yet this is necessary in the typal requirements.

Theoretically the first upper molars may differ slightly in their mesio-distal position, even in each lateral half of the dental arches of an apparently normal individual, just as the eyes or ears may slightly differ as to height or location in the same person. Probably the first molars are never exactly constant as to the two sides, but we insist that this is but natural and in keeping with the rest of the anatomy, and, when slight, should not be regarded as an abnormality.

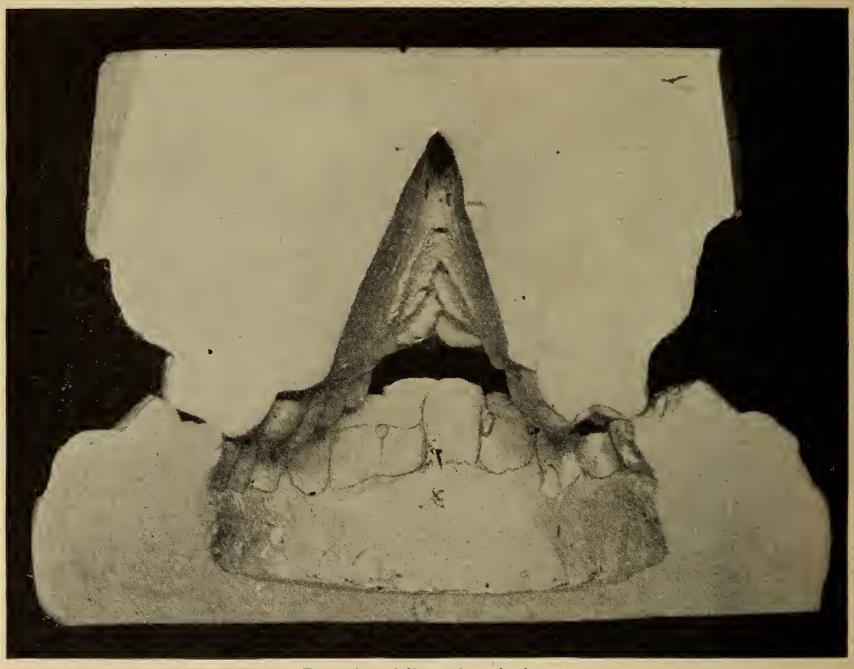
And finally, that nature may err in the mesio-distal locating of these molars is doubtless possible, for we know the unfortunates classified as "freaks" are the result of her anatomical errors, but we must remember that freaks are very rare, and we believe that nature so very rarely errs in the locating of the first upper molars—the very cornerstones, as it were, in the foundation of the structure of an organ so essential to the whole physical economy as the dental apparatus—as to make it a matter of little or no concern to us except, possibly, in research work. The writer has been unable to find, after much study, a single case in an unmutilated denture at maturity where it would seem to him that nature had erred in not locating these most important teeth so as to be in best keeping with the other anatomical factors of the type. Indeed, he is also greatly impressed, after the study of a large number of cases, with the constancy of the normality, also, of their linguo-buccal positions, in accordance with the age and growth of the individual, even when other unfavorable influences exist, unless the teeth are forced buccally or lingually by locking in buccal or lingual occlusion, as in Fig. 708.

So it will be seen that the reasons for regarding these teeth as the keys to occlusion are most logical and conclusive. It is, therefore, on their positions and the relations of their antagonists with them that the classification and diagnosis of malocclusion must be based.

The first upper molars are sometimes forced to take mesial malpositions temporarily, or during the growth of the denture, as a result of mutilation of either deciduous or permanent teeth, but this is only temporary, and the extent of their variation from normal position is easily determined and allowance for it made, and at maturity, or after the eruption of the second and third molars, it is probably rarely, if ever, even in these cases, that an upper first permanent molar is found mesial to its correct position. This subject is further discussed in the section on Premature Loss of Deciduous Teeth—Etiology.

Line of Occlusion.—Writers on orthodontia have long been in the habit of making use of an imaginary line, known as "the teeth in alignment," and "the line of the arch," from which to note regular and irregular alignment of the crowns of the teeth. It has most often referred to the general line of each individual arch, as outlined by the crowns of the teeth, regardless of their number or position, or of the relations of such lines to the skull. In this way two lines of occluson are often inferred, one for each arch, which may or may not have direct relation one to the other. In reality, as used, it has been vague and indefinite. So far as the writer is aware, none has comprehended its full meaning or importance.

FIG. 708



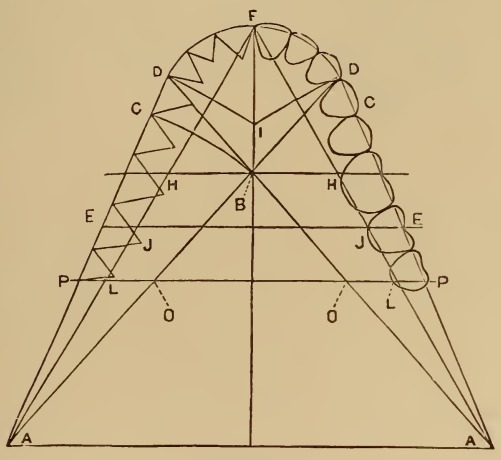
Buccal and lingual occlusion.

That we should have a line from which to note variations from the normal is highly important, but that its meaning is deeper and that it has a far greater significance to the student of orthodontia than above indicated, the writer is fully convinced, and he would define the line of occlusion as being *the line with which, in size, in form, and in position according to type, the teeth must be in harmony if in normal occlusion.*

There can be, then, but one true line of occlusion, and it is the normal architectural line on which the dental apparatus was designed. The ideal line was intended to govern not only the length, breadth, and peculiar curve of the dental arches, but the size and pattern of each tooth,

cusp, and inclined plane composing these arches. And more than this: that as the dental apparatus is only a part of the great structure—the human body—each part and organ of which was fashioned according to lines of design, it must have been intended that the line of occlusion should be in harmony in form and position with, and in proper relation to, all other parts of the great structure, according to the inherited type of the individual. Hence its majesty, and according to our conception of it must be our ability to comprehend not only the art requirements in each case we treat, but as well must it govern our conception of the requirements of the position of the teeth in occlusion and the various operations in treatment. The line of occlusion, then, is more than the tangible or material. It may be regarded as the basic ideal of the dental apparatus, the comprehension and appreciation of which will grow in proportion as our knowledge of the science of occlusion unfolds.

Fig. 709



Bonwill diagram.

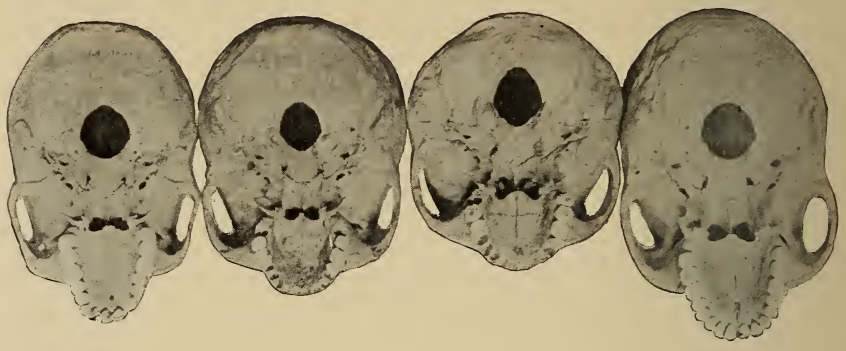
We may speak of moving a tooth of the lower arch into the line of occlusion, or of moving a tooth of the upper arch into the line of occlusion, but it must always be remembered that there can be but one true line of occlusion, or the line with which each tooth must be in perfect harmony if in normal occlusion.

It was long ago suggested by Dr. Bonwill, and very recently by others, that the well-known "Bonwill law," so called, could be made use of in predetermining the form and position of the line of occlusion in cases of malocclusion, the curve and width of the arch being determined by the combined diameters of the upper central and lateral incisors and canine on one side, as per the familiar diagram shown in Fig. 709.

The absurdity of this proposition is easily made apparent when we

remember that this would necessitate the same form of arch for every individual possessing the same diameter of incisors and canines, jointly, regardless of the demands of the facial type, when we know that in reality the width and form of the arch must vary, regardless of the width of the incisors and canines, according to the demands of the type. This is strikingly illustrated by the four skulls shown in Fig. 710. It will be seen that two of the arches are broad and short and the other two long and narrow, notwithstanding the fact that the diameters of incisors and canines may have been equal in all four cases.

Fig. 710



But by further study of these skulls it will be seen that each arch is in fine conformity with the demands of the architectural lines of the skull to which it belongs. The extremely broad and short arches are in perfect balance with the very broad and short skulls, while the long, narrow arches are also exactly in keeping with the extremely long and narrow skulls, and the patterns of the teeth are in like manner in perfect accord with the architectural demands of not only the skulls to which they belong, but to every portion of them. To make this point clear—if the face and skull are long and narrow, the dental arch will be long and narrow, and the body throughout will have the same typal characteristics.

If the face and skull are round, the dental arch will be proportionately round and broad, and the incisors and cuspids will conform more nearly to the arc of a true circle, and the rest of the body will be of a corresponding type. While with a type of face and skull more nearly approximating a cube, the dental arch and all the rest of the body will be found to correspond, and this same harmony and balance between dental arch, face, skull, and the rest of the body will also hold true with all individuals of whatever race who represent all the degrees and variations between these pronounced types. The writer believes this is a typal law,[1]

[1] The writer first called attention to this law in a paper read before the American Society of Orthodontists, September 29, 1905. See Items of Interest, June, 1906.

having few, if any, variations, which anyone can verify by the study of skulls or of individuals.

As there can be no fixed rules of measurement for predetermining the proper form of the line of occlusion in cases of malocclusion, any more than there can be fixed rules for determining the typal balance of the facial lines, for which artists have so long striven in vain, it seems to the writer that the best the orthodontist can do is to secure normal relations of the teeth and a typal form of the arch as nearly correct as he is able to determine, leaving the finer adjustment of this form to be worked out by nature through her forces governing occlusion, which must, it any event, finally triumph.

Forces Governing Normal Occlusion.—As we have already seen, the inclined planes of the cusps of the teeth play an important part in maintaining normal occlusion. They also exercise the most powerful influence in directing the positions of the teeth during their eruption.

When the teeth first emerge from the gums their considerable displacement is often noticeable, but this need occasion no uneasiness, provided, as eruption progresses, their cusps pass under the influence of normally placed opposing cusps. But if they pass beyond this influence into abnormal relations, they will not only be further deflected from their own proper positions, but may displace the opposing teeth and those subsequently to erupt as well, even to the extent of the disarrangement of the entire thirty-two teeth, as is possible from the mal-locking of the first permanent molars. So there may be times when the dividing line between harmony and inharmony is very slight, hence the importance of careful attention during the important period covering the eruption of the permanent teeth, especially the beginnings.

Harmony between the complete upper and lower arches is also powerfully promoted by their normal action and reaction upon each other through the teeth. As the teeth of the lower arch erupt before their antagonists of the upper arch, and are consequently to an extent fixed in their positions before the latter appear, it follows that the lower arch is the form over which the upper is moulded. In other words, the lower arch exerts a modifying influence on the form of the upper. Of course, the upper reacts upon the lower, but it is unquestionable, in the writer's opinion, that the lower arch is the more important factor in determining the form of the dental arches than the upper, as has formerly been taught.

From what has been said it may be readily seen how greatly each arch contributes to the other in maintaining its form and size when the teeth are in normal occlusion, and how pressure abnormally exerted on any tooth or teeth would be resisted by all the other teeth. For example, pressure exerted on the labial surfaces of the upper incisors would be resisted not only by all the upper teeth acting as blocks of stone do in an arch of masonry, but also by the teeth of the lower arch acting through occlusion.

Inversely, then, one arch cannot be altered in shape without modifying that of the other, nor can it be altered in size without soon exercising a marked effect on the other.

The normal positions of the teeth and the normal sizes and relations of the arches are further powerfully influenced by another force, namely, muscular pressure, the tongue acting upon the inside and the lips and cheeks upon the outside of the arches. The latter, if normal in development and function, serve to keep the arches from spreading, as do hoops upon the staves of a cask; the former prevents too great encroachment upon the oral space, and each, if normal in function, contributes in like proportion to the harmony of balance. The upper lip will be found to rest evenly in contact with the gums and upper three-fourths of the labial surfaces of the upper incisors, leaving, however, about one-fourth

Fig. 711



of the occlusal ends of the central incisors and laterals to be covered by the edge of the lower lip, so that normally there is a restraining force exerted upon the upper incisors by both upper and lower lips.

This force is exerted automatically in response to almost every emotion, and results in maintaining the teeth in harmony with the graceful and beautiful curve of the normal individual arch. This muscular pressure is far more important than is generally recognized.

Fig. 711 represents the teeth of a child, aged eight years, where the jaws and teeth are developing normally. It will be noted that all of the permanent lower incisors have erupted and occupy their normal positions in the line of occlusion, each occupying its full mesio-distal space in the arch, compelling the lower canines to occupy positions the requisite distance apart. Of special importance is the influence that these teeth

exercise on the opposing deciduous canines through their inclined planes, each blow that the upper canines receive from the lower tending to widen the upper arch, or at least to prevent it from becoming narrower through the pressure of the lips.

So it will be seen that normal occlusion of the teeth is maintained, first, by harmony in the sizes and relations of the dental arches through the interdependence and mutual support of the occlusal inclined planes of the teeth; and secondly, by the influence of the muscles labially, buccally, and lingually. Of course, there are other forces in the normal building and maintaining of the dental apparatus, such as structural growth of all the various bones and tissues, the influence of co-related organs, air pressure and mental influences, all, if normal, contributing to the perfect balance and integrity of the whole. It is needless to say that such normality would only be possible with normal balance of all of the forces governing growth and occlusion.

Forces Governing Malocclusion.—In beginning the consideration of malocclusion, let us remember that it is but the perversion of the normal growth and development of the denture—the side-tracking, as it were, of nature in some of her normal processes of building, and we would repeat and insist that before anyone can intelligently comprehend malocclusion, he must have as a basis from which to reason in determining its extent and complexity, a thorough knowledge not only of the normal growth and development of the dental apparatus, but that of the co-related organs and also a knowledge of their functions and interdependence.

We know that every case has a simple beginning in its variation from the normal, and that very often a single tooth, from slight cause, being deflected from the normal, may and usually does ultimately involve others. The dividing line, then, between the normal and the abnormal in the beginning is very slight, but always clearly defined, so the normal in occlusion is the only logical basis for determining the variation therefrom and the extent of the abnormal—malocclusion—and, as we shall see, the same forces that contribute to maintaining the teeth in their normal positions and harmony in the sizes of the arches are equally powerful when perverted in maintaining inharmony in the sizes and relations of the arches and malocclusion of the teeth.

In a large percentage of cases of malocclusion the arches are more or less contracted, and as a result we find the teeth crowded and overlapping. In these cases the lips serve as constant and powerful factors in maintaining this condition, usually acting with equal effect on both arches, and effectually combating any influence of the tongue or any inherent tendency on the part of nature toward self-correction. In other words, the arches, narrowed and diminished in size, are so maintained by force from the lips, equal in power to that exerted for their normal maintenance when of normal size and relation, with the teeth in normal occlusion.

Likewise each inclined plane of the cusps once out of harmony serves not only to maintain the inharmony, but to increase it, upon each closure of the jaw.

It is interesting and instructive to note the result of these perverted forces even in very early indications of malocclusion.

Fig. 712

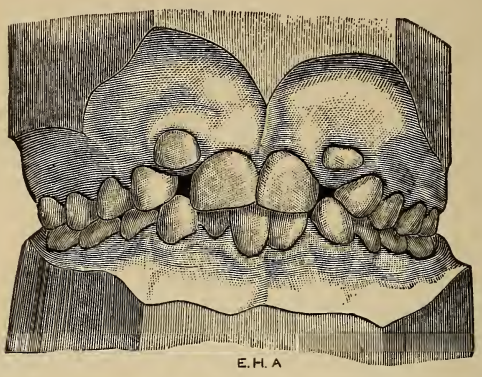
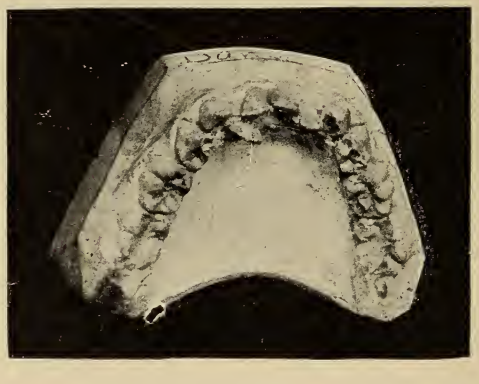


Fig. 712 illustrates a very common and familiar form of developing malocclusion. The case is that of a child where the four lower permanent incisors are fully erupted, but one of them (the left lateral) has been deflected lingually (Fig. 713). Being thus deprived of the wedging and retaining influence of this tooth, the pressure of the lips

Fig. 713



has closed the space and diminished the size of the lower arch. At the same time pressure, principally from the lips and cheeks, aided by the occlusal planes of the lower deciduous molars, is gradually moulding the upper arch to conform to the diminished size of the lower.

It will thus be seen how effectually the malocclusion will be maintained and how hopeless it is to expect nature to correct this deformity

unaided. These perverted forces are traceable in all cases of malocclusion.

Recognizing the potency of their influence, it must be apparent that cases of this kind, instead of being self-corrective, will become more and more complicated as time goes on and as each succeeding permanent tooth erupts. How absurd and unfortunate, then, is the common daily advice of many dentists to anxious parents to "let the teeth alone and nature will correct them unaided."

In all such cases the position of the erupting permanent lower incisors should be guarded with zealous care, placed in correct positions, and maintained therein, that they may, through occlusion, assist in directing the teeth of the opposing arch into normal positions and be compelled to fulfil their important part in the full normal development of the alveolar process. This is the golden opportunity for beginning intelligent interference for the prevention of what might otherwise become complicated cases of malocclusion. This also applies with equal force to any other lower tooth that may erupt into abnormal position, especially the lower first molars. If the lower teeth erupt in their normal positions either naturally or through proper treatment, the upper teeth will usually take their normal positions.

For the reason previously stated, if the teeth of the lower arch be permitted to remain in malposition even to the slightest overlapping of one or more of the incisors or canines, the arch will be diminished in size just to that extent, and as a result of pressure of the lips there will be a corresponding contraction in the upper arch and some form of bunching of the teeth, especially in Class I.

The influence of the lips in modifying the form of the dental arches is an interesting study, and almost every case of malocclusion offers some noticeable and varying manifestation of it. Indeed, the forces from perverted lip and cheek function are far more potent and frequent causes of malocclusion than has heretofore been recognized. This phase of this question will be further discussed under the sections on Etiology of Malocclusion and Treatment.

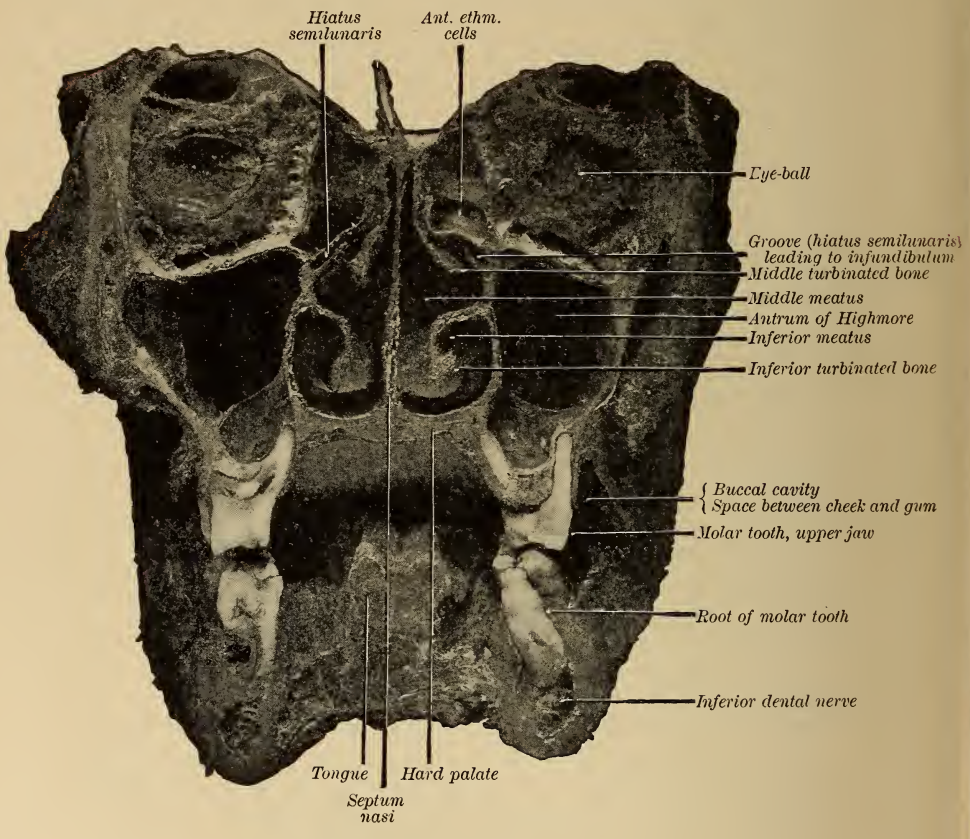
The result of pressure from the tongue in exerting force upon the inside of the arches is also a factor, we are convinced, of great importance in determining the form of the arches and the positions of the individual teeth. That when normal in size, tone, and function, it exercises a gentle force upon the inside of the arch, which is in perfect harmony with the force exerted by the muscles upon the outside in maintaining the correct balance in muscular pressure upon the teeth, is well known, but when these forces are perverted, through abnormal size or function of the tongue, the result is most noticeable and characteristic in the malpositions into which the teeth are forced. This subject will also be further discussed in the section on Etiology.

The transferring of force from air pressure from the floor of the nose

in nasal breathing, to the vault of the arch in mouth breathing, is doubtless also a factor of much importance in the development and maintaining of malocclusion.

When the teeth are in normal occlusion the influence of the inclined occlusal planes and the relations of the crowns and roots of the teeth are such that the great weight or force that each must bear in occlusion is in perfect balance with a line of axis common to both dental arches, as shown in Fig. 706, this line of axis being such that the force does not tend to displace either crowns or roots of the teeth either lingually

FIG. 714



or bucally, mesially or distally, but instead is such as best to stimulate the normal growth of the jaws, palate, and nasal bones, and probably all other bones and tissues of the face, and best to maintain their normal size and harmony of relations. But when the line of stress is changed from the normal axis to one that is abnormal, as when all the upper buccal teeth are in lingual occlusion, the result is to disturb the balance greatly, and force the roots and crowns of the upper teeth lingually

and those of the lower buccally. How powerful is the force when so perverted is shown in the remarkable case illustrated in Fig. 708.

By studying this picture in comparison with the one shown in Fig. 714, it is easy to realize how greatly the normal development of the vault of the arch and the bones of the nose has been interfered with by this perversion of force.

Another lesson is also here impressed, namely, how interdependent are the work of the rhinologist and that of the orthodontist, and *vice versa*, and how utterly useless for either to hope for success in the treatment of many of these cases without the assistance of the other, and how important that both should coöperate as early as possible in their work of establishing the normal forces of growth and development.

CLASSIFICATION OF MALOCCLUSION

Nomenclature.—All teeth found out of harmony with the line of occlusion may be said to occupy positions of malocclusion, and each tooth may occupy any of seven malpositions or their various deviations and combinations.

FIG. 715



The malpositions of teeth consist principally in the variation of the positions of their crowns from the normal, with usually little displacement of the apices of their roots, so that they incline at an angle more or less oblique from the normal. In some instances, however, there is some displacement of the apices as well as of the crowns, they having

either developed in malpositions, or, as in most instances, having been forced from their normal positions by mechanical influences, or the eruption of more powerful teeth in juxtaposition, as, for example, the crowding lingually of the lateral incisors by the development and eruption of the canines, as in Fig. 715. Yet even in such cases the displacement is not so great as appears, the malpositions of the crowns magnifying this appearance.

A definite nomenclature is as necessary in orthodontia as in anatomy. The vagueness of descriptive terms often used renders them very inadequate. The terms for describing the various malpositions of teeth should be so precise as to convey at once a clear idea of the nature of the malocclusion to be corrected. The author therefore suggests the following, which, while perhaps not perfect, still seems to be a great improvement on common usage.

For example, a tooth outside the line of occlusion may be said to be in buccal or labial occlusion; when inside this line, in lingual occlusion; if farther forward, or mesial, than normal, in mesial occlusion; if in the opposite direction, in distal occlusion; if turned on its axis it would be in torto-occlusion. Teeth not sufficiently elevated in their sockets would be in infra-occlusion, and those that occupy positions of too great elevation, in supra-occlusion. These terms used singly or in combination will accurately describe the malpositions of any tooth or teeth in any case of maloccusion, from the simplest to the most complex, and used in connection with the writer's classification, make possible the conveying of a very complete picture of any given case of malocclusion in very few words.

Although the number of cases of malocclusion is limitless, in no two do we find the arrangement of the teeth alike, even in those strikingly similar cases of Division 1, Class II.

Yet, notwithstanding this endless variation, which has led to endless confusion in diagnosis and treatment among the old school writers and practitioners, as we shall see, all cases of malocclusion fall naturally into a very few distinct and easily recognized groups, or three great classes, with their divisions and subdivisions, and when so classified the extent of the variation from the normal in each case is easily comprehended and the requirements of treatment made manifest.

The classification of malocclusion is based on the mesio-distal relations of the teeth, dental arches, and jaws, which depend, primarily, in the permanent denture, upon the positions mesio-distally assumed by the first permanent molars on their erupting and locking. Hence in diagnosing cases of malocclusion we must consider, first, the mesio-distal relations of the jaws and dental arches, as indicated by the relation of the lower first molars with the upper first molars—the keys to occlusion, and secondly, the positions of the individual teeth, carefully noting their relations to the line of occlusion.

Class I, illustrated by Figs. 716 and 717, is characterized by normal mesio-distal relations of the jaws and dental arches, and normal locking of the first molars; that is, mesio-distally. One or even all of the molars may be in buccal or lingual occlusion, but this is only an incident and may occur in any class, and is not constant in, nor a characteristic peculiar to, any particular class.

In this class the malocclusion ranges from the slightest overlapping of a single tooth to the most complex derangement, involving the positions of all of the teeth in both arches, as in Fig. 872. In the average case (Figs. 716 and 717), however, the arches are more or less shortened and reduced in size, with a corresponding crowding of the teeth.

Fig. 716 Fig. 717



Class II.—When the lower jaw is distal to its normal relation with the upper jaw, and the lower first molars lock distally to normal, it must necessarily follow that every succeeding permanent tooth to erupt must also occlude abnormally, all the lower teeth being forced into positions of distal occlusion, causing retrusion and more or less underdevelopment, of the entire lower jaw.[1] This condition of distal occlusion is the determining characteristic of Class II.

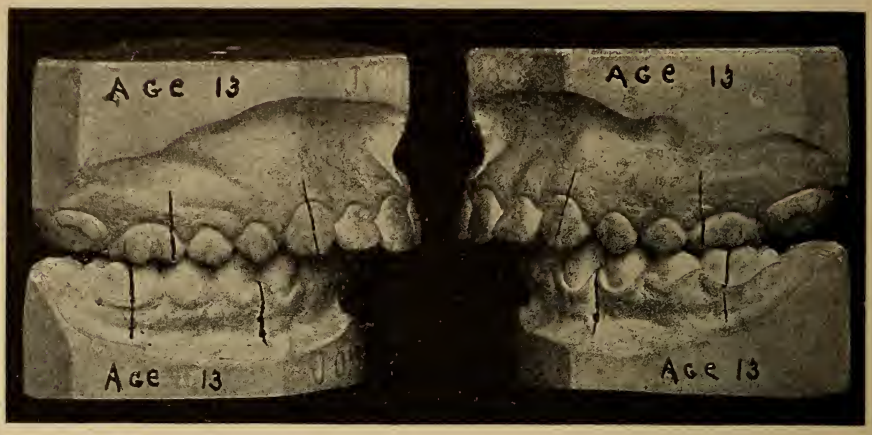
Of this class there are two divisions, each having a subdivision:

Division 1 is characterized by distal occlusion of both lateral halves of the lower dental arch, a narrowed upper arch, protruding upper

[1] In this classification the writer has selected typical cases representing the first permanent molars in distal or mesial occlusion (in Classes II or III) the full width of the cusp, but it should be remembered that the *complete* distal or mesial locking of the molars is unnecessary to the correct placing of cases in their proper classes, but the mal-locking of the inclined planes of the cusps must be such as ultimately will lead to their full mesial or distal locking. See also pages 687 and 688.

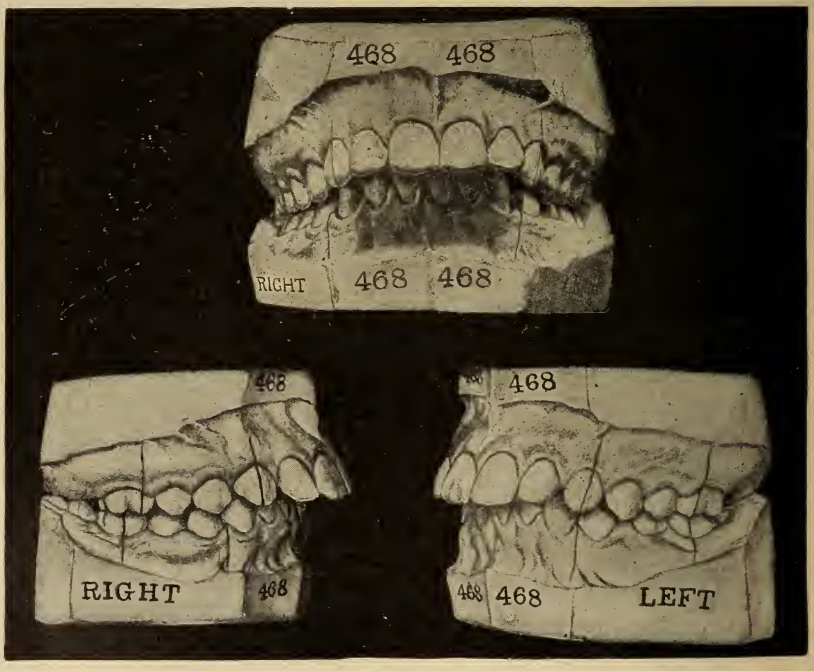
incisors, short and practically functionless upper lip, lengthened lower incisors, and thickened lower lip which rests cushion-like between

Fig. 718



the upper and lower incisors, increasing the protrusion of the former and the retrusion of the latter. A like condition is sometimes found in

Fig. 719

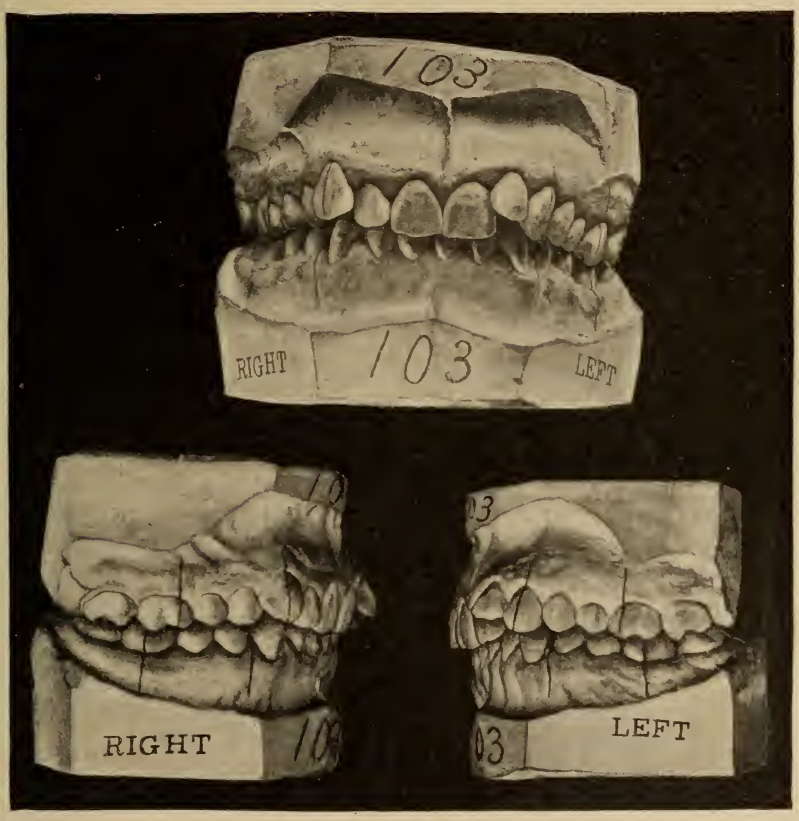


younger patients who have as yet erupted only their deciduous teeth. It seems probable that cases of malocclusion belonging to this division

of this class are caused by some form of nasal obstruction necessitating mouth-breathing, which is usually an accompaniment—probably always in the early stages.

There is great similarity in the malocclusion in cases belonging to this division, and the disturbance in the facial lines is also characteristic and pronounced. The malocclusion typical of this division of this class is shown in Fig. 718.

Fig. 720



Subdivision, *Division 1*, has the same characteristics, differing only in that the distal occlusion is unilateral, as shown in Fig. 719. This condition may also be found in the deciduous denture.

Division 2 is characterized also by distal occlusion of both lateral halves of the dental arches, but by retrusion instead of protrusion of the upper incisors. In this division there are no complications from pathological conditions of the nasal passages, hence the mouth is kept closed the normal amount of time, and the lips perform their normal functions, which causes the repression of the upper incisors until they come in

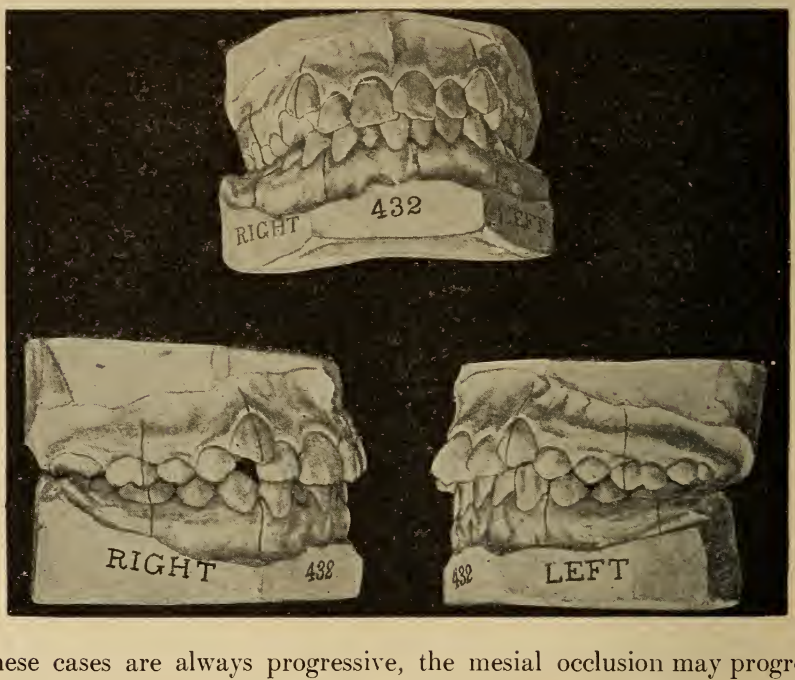
contact with the lower incisors, causing bunching and overlapping of the upper incisors and canines, as shown in Fig. 720.

Subdivision, Division 2, has the same characteristics as Division 2, differing chiefly in that the molar occlusion is unilaterally distal, as shown in Fig. 721.

The marring effect on the facial lines of the malocclusion of Division 2 and its subdivision is both marked and characteristic, but very different from that of Division 1 and its subdivision.

Class III is characterized by the locking mesially to their normal relations of the inclined planes of the lower first molars in both lateral halves of the dental arches. This is but slight in the beginning, but as

Fig. 721



these cases are always progressive, the mesial occlusion may progress to include the full width of one or even two cusps, as in the extreme case shown in Fig. 722. In cases belonging to this class, the arrangement of the teeth in their respective arches varies greatly from quite even and regular alignment to considerable crowding, especially in the upper arch. There is usually a decided lingual inclination of the lower incisors and canines, which becomes more and more pronounced as the case progresses, and which is due to the pressure of the lower lip in the effort to close the mouth.

In addition to the inharmony in the relations of the jaws, there is usually inharmony also in the sizes of the two dental arches, especially in fully developed cases, due to the asymmetrical development of the

Fig. 722

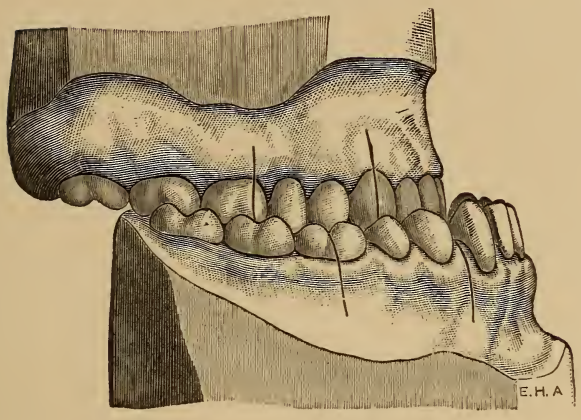
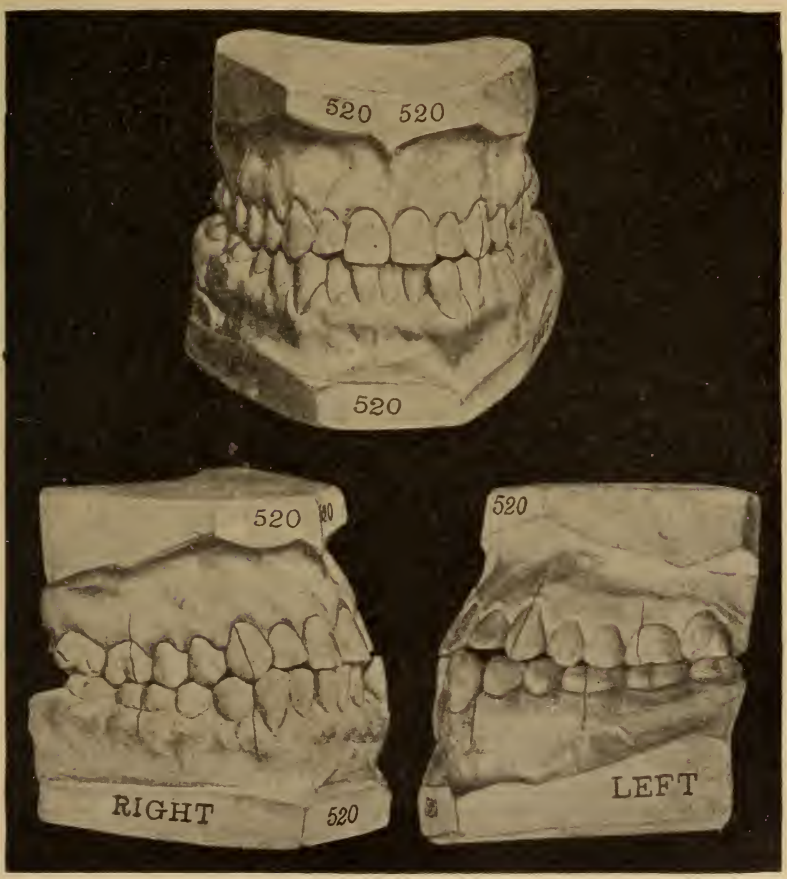


Fig. 723



maxillary bones, the angle of the lower jaw being more obtuse than normal, but it may also be the result of overdevelopment in the body of the jaw. Other characteristics met with in this class are considered in the section on Treatment, page 864.

In all cases belonging to this class the marring of the facial lines is most noticeable, and in direct proportion to the extent of malocclusion.

Subdivision, Class III.—This subdivision differs from the division only in degree, one of the lateral halves of the arch only being in mesial occlusion, the other being normal, as shown in Fig. 723, the arches crossing in the region of the incisors.

That all cases of malocclusion met with will be found to be embraced in the above classification is more than probable. There still remains, however, one possible class—viz., where one of the lateral halves of the lower arch is in mesial occlusion while the other is in distal occlusion; but cases having these characteristics are so very rare that no further reference to them is necessary, the writer having never seen but two or three cases.

In diagnosticating cases according to the above classification, it will be seen that the occlusion of each of the lateral halves of the arches is important, and must be considered separately and with equal and careful attention, always beginning with the first permanent molars. In cases of malocclusion of very young children who have only their deciduous dentures, diagnosis should begin with the second deciduous molars.

In developing cases of the second and third classes when the lower jaw may be in a state of transition and has not attained to distal or mesial occlusion the full width of a cusp on one or both sides, the beginner may be a little puzzled as to the proper classification; but upon careful inspection and close study a majority of the inclined planes will be found to favor one particular class, the co-relation of the first molars being, of course, the most important factor.

The loss of a tooth or teeth by extraction is followed by such marked changes in the positions of the remaining teeth that diagnosis is sometimes greatly complicated. Therefore, great care and judgment should be exercised, making allowance for the tipping of teeth and other changes which have taken place as a result of extraction, in order to determine their original positions. This point being decided, the correct diagnosis according to the above classification becomes easy.

A brief recapitulation of the classification is here given for convenience of study and for ready reference:

Class I.—Arches in normal mesio-distal relations, with malocclusion of anterior teeth.

Class II.—Lower arch distal to normal in its relation to upper arch.

Division 1.—Bilaterally distal, protruding upper incisors. Usually mouth-breathers.

Subdivision.—Unilaterally distal, protruding upper incisors. Usually mouth-breathers.

Division 2.—Bilaterally distal, retruding upper incisors. Normal breathers.

Subdivision.—Unilaterally distal, retruding upper incisors. Normal breathers.

Class III.—Lower arch mesial to normal in its relation to upper arch.

Division.—Bilaterally mesial.

Subdivision.—Unilaterally mesial.

Out of several thousand cases of malocclusion examined, the proportion per thousand belonging to each class was as follows:

Class I	692
Class II.	
Division 1	90
Subdivision	34
Division 2	42
Subdivision	100
Class III.	
Division	34
Subdivision	8
	1000

FACIAL ART

Art, as related to the human face, must ever have an important bearing on the study of orthodontia, for the mouth is a most potent factor in making or marring the beauty and character of the face, and the positions of the teeth are to a very large extent responsible for the proper form and beauty—or the lack of it—of the mouth. No one can be beautiful unless the mouth is in harmony with all the other features, and no one afflicted with malocclusion can have a mouth that is thus in harmony.

The duties of the orthodontist force upon him great responsibilities, and there is no subject in which the student of orthodontia should be more keenly interested nor better informed than in art generally, and especially as it relates to the human face; for each of his efforts, whether he realizes it or not, makes for beauty or ugliness, for harmony or inharmony, for perfection or deformity.

But in order that our efforts may be intelligently directed toward the ideal, there must be some grand principle as a basis from which to reason, or we must be but gropers in the dark, experimenters, producing results which may cause embarrassment or even bitter regret.

Though human faces are all greatly alike, yet all differ. Lines and rules for their measurement have ever been sought by artists, and many have been the plans for determining some basic line or principle from which to detect variations from the normal, but no line, no measurement, admits of anything nearly like universal application.

The beautiful face of the Apollo Belvedere has very largely been used as a guide toward the ideal and from which to judge variations, but this has been found to be impracticable and misleading; and this is easily understood when we remember that the Apollo face represents the type of the ideal Grecian beauty, while now the Greek type is rarely seen, and in its place we have, especially in America, many types and the greatest number of variations of each type, each face being a law unto itself, and presenting demands as to measurements and proportions wholly peculiar to itself.

According to one of our foremost teachers of art, Mr. E. H. Wuerpel, there *is* a principle for our use which is equally applicable to all faces—viz., the principle of balance, of symmetry. We must be able to detect whether the features—that is, the forehead, the nose, the chin, the lips—of each individual face balance, harmonize, or whether they are out of balance, out of harmony, and especially whether the mouth is in harmonious relations with the other features, and, if it is not, what is necessary to place it in balance.

The faculty of determining the proper balance of the features is a difficult one to attain. The authority above referred to says that only one in two or three hundred art students ever succeed in mastering it, and these only after much observation and practice in sketching and modelling faces.

Unpromising as this seems, it is doubtless correct, yet we have a rule for determining the best balance of the features, or at least the best balance of the mouth with the rest of the features, that artists probably know nothing of, and one that for the orthodontist is more unvarying and more reliable than even the judgment of the favored few—a rule so invariable and with so few exceptions that we may consider it a law, and if it be not applicable in all cases, the exceptions will be so very rare that they are hardly worth considering. It is, furthermore, a rule so plain and so simple that all can understand and apply it. It is that the best balance, the best harmony, the best proportions of the mouth, in its relations to the other features, require that there shall be the full complement of teeth, and that each tooth shall be made to occupy its normal position in the architectural line of occlusion according to each individual type—normal occlusion.

Fig. 724 shows the face of Apollo. The face is a study of symmetry and harmony of proportion, and such lines are wholly incompatible with teeth in malocclusion or with less than the full complement of teeth.

Fig. 725 shows another face, which is also one of much beauty and fine proportions. It is also somewhat of a Greek type, and the lower half of the face shows lines which could only have been moulded over teeth normal in number, type, size, and position, and accompanied by normal conditions of development and nasal function.

Fig. 724



Fig. 725



Fig. 726



Fig. 726[1] shows a face that is a blending of the Greek and Roman types, and it also is in fine balance, although very different from that of

[1] William Whipple.

Apollo. The features are large and prominent and the head is large, but there is a harmony of size, relation, and proportion that forms a most pleasing whole. The face, while in fine balance, is perhaps not

Fig. 727



Fig. 728



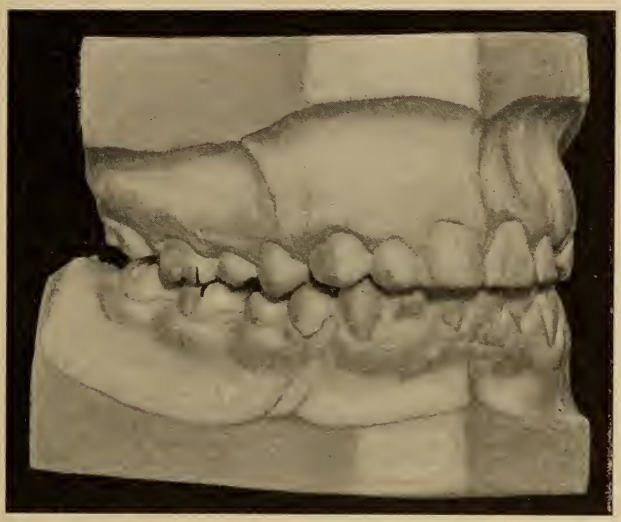
Fig. 729



beautiful from a physical standpoint, but it is more. It is beautiful from an intellectual standpoint, possessing strength, nobility, majesty—that, in the writer's opinion, is lamentably lacking in the Apollo face.

Figs. 727 and 728, and Fig. 729 show the faces of two normally developing children, although it will be observed that they are of strikingly different types. The proportions of the faces, the balance of the features,

Fig. 730



and the harmonious lines of the mouths tell as truthfully that they are being moulded over dental arches developing normally, with teeth in normal occlusion, as the models of the teeth themselves, shown in Figs. 730 and 731.

Fig. 731



In these cases nature has been able to work unhampered by detrimental pathological conditions, which is apparent in the results.

Of course, it must be understood that changes in the contour of these young faces must take place with greater development. The noses and chins will develop and become more prominent, and after the eruption of the permanent canines there will be more of an acute angle between the nose and the upper lip, especially in the face shown in Fig. 729. But the point we would emphasize is the normal development and consequent normal balance and symmetry of these faces, and if we will notice any child that is developing normally, or any person who has reached maturity with the teeth in normal occlusion, we will find an equal harmony of balance of the mouth with the other features. Dr. R. Anema has well said that "probably the greatest reason why there is such uniformity of harmony in the facial lines of young children is that their teeth (the deciduous teeth) are so free from malocclusion."

Fig. 732



The writer would not be understood as implying that every face with lines and features in harmony of balance must necessarily be beautiful, nor even that placing malocclucded teeth in normal occlusion will always put the whole face in harmony of balance. There may be defects in the face, as lack of development of the nose or chin, or unequal development of the malar bones or of any of the bones of the face, or defects in the eyes or ears, or in the shape of the head, which, of course, could not be remedied by the correction of malocclusion alone, but the best harmony of such faces, or of any face, is only possible when the teeth are in normal occlusion. Malocclusion, or the loss of teeth by extraction or non-eruption, or a combination of these two causes, is responsible for far more faces out of balance and out of harmony than any other cause or combination of causes, and this inharmony and lack of balance of the mouth exists just in proportion to the degree of malocclusion.

For a true understanding of what is meant by harmony of proportion and balance of faces, a careful study must be made of faces that are out of balance as well as of those that are in balance.

The effect on the facial lines of the varying forms of malocclusion found in the three different classes varies not only with the degree of malocclusion, but also with the individual type of face, yet, notwith-

standing this, the type of facial deformity produced by each separate class of malocclusion is so constant that, after some practice, the close observer may classify with much accuracy the malocclusion of the people he observes without an actual examination of their teeth. This is also true in the case of extraction, or the loss or lack of teeth from any cause.

Fig. 733



In Class I, the chin and nose will usually be found in relatively normal balance with the forehead and general contour of the face, and the lines of abnormality confined more or less to the mouth itself.

Fig. 732 shows such a case in the profile of a boy, aged fourteen years, and the lack of balance in the flat and sunken lines of the mouth clearly indicates diminished sizes of the dental arches. This lack of normal contour of the mouth will be more impressive when it is remembered that at this age a boy's mouth should be relatively more prominent than that of a man, for the reason that his face has not yet reached its full growth, while the teeth are full-sized at eruption.

Figs. 716 and 717 show the reason for this lack of normal contour, namely, lack in the development of the alveolar process and pronounced crowding of the teeth.

The correctness of our rule is verified in the corrected occlusion, shown in Fig. 884, and in the restored facial lines in Fig. 733.

Fig. 734 shows the profile of a young girl whose malocclusion belongs to Division 1, Class II, and the lines of inharmony shown in this face are characteristic of all cases of this division of this class of malocclusion, and also of the subdivision.

In cases belonging to Class I, as we have seen, the mouth is the only feature greatly out of harmony; but in these cases the nose, the mouth, and the chin must be greatly out of balance, both with each other and with the general contour of the face, due to the type of malocclusion of this class, as illustrated in Fig. 718.

Fig. 734



Fig. 735



To attempt to restore balance and harmony of proportion to this face by placing all the teeth in normal occlusion is perhaps to seem to put our rule to a severe test, but its correctness is shown in the result on the facial lines in Fig. 735, and while the face may still not be beautiful, we believe that by no other means could it have been placed in so nearly normal balance or harmony.

It will be observed that this type of face differs greatly from the straight-line Apollo face; yet in cases of malocclusion both types of face are equally susceptible of being restored to the correct balance normal to each, and both by the same method—namely, the establishment of normal occlusion.

Since in this case there have been established normal relations of the muscles and of the inclined planes of the teeth, and normal nasal respiration has also been established, the further development of this face

will be toward the normal—toward harmony—instead of in the opposite direction, as had been the case since the day the nasal trouble first caused mouth-breathing, or since the first abnormal locking of the inclined planes of the first permanent molars.

The disturbance of balance of the facial lines in the subdivision of this division differs, usually, only in degree.

Fig. 736 shows the profile of a young man's face which is fairly typical of the lack of balance of facial lines due to malocclusion of the second division of Class II. The malocclusion is shown in Fig. 928.

Fig. 736 Fig. 737



The head is large and well shaped, and the forehead and nose strong and in good balance, but there is a weakness about the mouth and chin that is greatly out of keeping with the general contour of the head.

We have but to study the malocclusion to readily detect the cause, namely, distal occlusion with normal nasal and lip functions which have pushed the upper incisors back to occlude with the lower incisors and caused a crowding and overlapping in the upper canine region.

Again, the rule was applied and each tooth made to occupy its normal position in the line of occlusion, with the most gratifying result on the facial lines, shown in Fig. 737. Those weak lines of inharmony have been changed to others of strength and harmony of balance, in contrast to the lines that must have followed had extraction been resorted to as the plan of treatment.

The restored occlusion is shown in Fig. 929.

The disfiguring effect on the face caused by malocclusion of the subdivision of this division of Class II are similar to those just shown in the full division.

Fig. 738 shows the profile of a girl, aged thirteen, whose facial lines were thrown out of balance by reason of malocclusion of Class III, as shown in Fig. 948.

A very superficial study of the malocclusion is sufficient to show us the reason for the flat upper lip and unnatural prominence and heaviness of the chin and lower lip.

The applying of our rule, or the establishing of normal occlusion, produced the result in facial lines shown in Fig. 739, and in occlusion shown in Fig. 949.

The subdivision of Class III is characterized by the same type of facial disturbance as the division.

Fig. 738



Fig. 739



Thus far we have considered the marring effect on the facial lines resulting from malocclusion when the normal number of teeth is present; but there is another phase of malocclusion, the effects of which are very pronounced in the disturbance of the facial balance, namely, the all too common loss of teeth from mutilation by extraction, or their occasional non-development, or non-eruption, and the disturbance in facial balance will be in exact proportion to the extent of the loss or lack of teeth.

The loss of even a single tooth not only produces great inharmony of occlusion, but equal inharmony in the facial lines. Fig. 740 shows the profile of a young girl whose upper right lateral incisor failed to develop, as was revealed by the *x*-rays, and the resultant inharmony in the relations of the upper and lower lips, as well as the unpleasing angle between the upper lip and nose, is readily seen. It can be imagined how great would have been the improvement in the facial lines had that tooth developed normally and the upper arch been enlarged to accommodate it.

Since this is true, what must we think of the frequently advocated practice of extracting one or both lateral incisors or even canines in the hope of improving the facial lines?

The profile on the left of Fig. 741 shows the effect on the facial lines of an effort to prevent malocclusion by the extraction of the perfectly sound four first permanent molars at the age of nine years, which is in keeping with a belief still practised by many of the old school. We need possess very little artistic perception to readily detect the great inharmony of the mouth with the other features. The lack of balance is so pronounced as possibly to create the impression that all the teeth have been lost, and that the patient is wearing badly proportioned artificial dentures.

FIG. 740



The profile on the right of Fig. 741 shows the facial lines restored to normal balance, or as nearly so as was possible at that age of the patient, established by the placing of the teeth that remained in their normal relations. Fig. 899 shows this, and the case ready for the insertion of artificial substitutes for the missing molars.

Fig. 742 shows the profile of a face where extraction of both upper first premolars was resorted to by the writer several years ago in carrying out the old plan of treatment for the reduction of "labial protrusion of the upper incisors," or a case belonging to Division 1 of Class II. The effect of this treatment, instead of improving the facial lines, especially the angle of the nose with the upper lip, was to cause their greater inharmony and has been the occasion of lasting regret.

The writer wishes to indelibly impress on the mind of the student that since normal balance of the lines of the mouth with those of the other features is dependent on the normal occlusion of the teeth, they are necessarily thrown out of balance and out of harmony just in proportion

Fig. 741



Fig. 742



as the teeth are out of normal occlusion, and that since extraction always produces malocclusion just in proportion to the number of teeth extracted, where malocclusion did not previously exist, and exaggerates and complicates it where already existing, its effect on the facial lines is inevitably as inharmonious, not to say deforming, as its practice is unpardonable.

Extraction is further discussed in the section on Treatment.

ETIOLOGY OF MALOCCLUSION

As we have already noted, malocclusion is the result of failure on the part of nature to carry to completion the normal plan of building the human denture—the arrest or modification of the forces operative in the building. As these forces are numerous and necessarily complicated by their co-relations, it is not surprising that the perfectly normal human denture is rarely found. Indeed, the perfectly normal in dentures, as in human beings, or in the lower animals, or in plants, is rare. If the conditions for growth and development of the teeth and jaws, bones of the face, the throat, the nose, the muscles, etc., are normal, a normal denture will be the result; but a long time is necessary for the building of the denture, and many obstacles may intervene to prevent its normal unfoldings in growth. Indeed, any pronounced interference with the growth of any of the different factors may, and usually does, result in malocclusion of the teeth. As, for example, any pathological condition of the nasal passages, resulting in the necessity for mouth breathing, will not only prevent the normal growth of the nose, but will modify the vault of the arch, and so pervert the forces of the lips as to cause serious disturbance in the dental arches and the relations of the teeth, as is shown in cases belonging to Division 1, Class II. And not only this, but serious disturbances in the growth, health, and development of the child also often result from mouth breathing. Again, it is the writer's belief that abnormal enlargement of the faucial tonsils is the principal cause in the production of malocclusion belonging to Class III, at least in the primary stages, the enlarged tonsils seeming to provoke a desire on the part of the child to habitually shove the lower jaw forward until mal-locking of the cusps of the molars results. Thus, perversion of occlusal and muscular forces is brought about and the most progressive of all forms of malocclusion established.

Premature Loss of Deciduous Teeth.—The deciduous teeth not only perform the important function of masticating the food required by the child up to the period of their normal loss and their replacement by the succeeding permanent teeth, but they also assist in a mechanical way in the development of the alveolar process, and probably in the development of the jaws as well.

The permanent teeth being larger and more numerous than the deciduous, the greater space required for them is provided principally by the lengthening of the lateral halves of the dental arches. This is influenced largely by the development and eruption of the permanent molars posterior to the deciduous molars. If the mesio-distal diameters of the deciduous teeth be not impaired by caries and the teeth remain the normal period, the first permanent molar in taking its position in the arch must force its way between the second deciduous molar and the ramus of the jaw, if below, or the maxillary tuberosity if above.

Coincident with the growth of the bones of the head and face the maxillary bones are developed downward and forward, the mandible lengthened and deepened, and the deciduous teeth carried forward. If, however, one of the deciduous teeth be prematurely lost, as, for example, the upper second molar, the erupting permanent molar will be unable to exert its normal force in crowding the deciduous teeth forward, but instead, meeting with no resistance, it will move forward prematurely and more rapidly than normal, into the space of the missing tooth. If, meanwhile, no teeth have been lost in the same side of the opposing arch, the wedging process will have pushed forward the lower deciduous teeth and the more normal development in the lower arch will have occurred. There will thus be an inequality between the jaws on the affected side with the establishment of malocclusion. And this is not the only evil, for the space occupied by the lost tooth having been closed or greatly diminished, the eruption of the succeeding permanent tooth (the second premolar) will be prevented entirely, or it will be forced into buccal, or, possibly, lingual occlusion, as in Figs. 743 and 744. The shortened lateral half will not develop, and the upper arch will consequently be smaller than normal, which must result in malocclusion of the teeth.

A point of much importance in connection with this phase of the subject which may as well be discussed here is that, although the first permanent molar is temporarily displaced by its moving *prematurely* forward, the writer believes it is always found in its normal mesio-distal position, even in these cases, ultimately, or at the time of the completion of the denture. Indeed, even in two cases in each of which three upper premolars had failed to develop, the first permanent upper molars were not found farther mesially than normal at the maturity of the patient. And the reason is plain. There was nothing to force them forward after the second and third molars had taken their places in the arch and ceased their wedging influence, all the lack of development of the arch, which was great, being in its anterior portion.

This premature movement of the molar to its ultimately normal position is easily understood by a study of Figs. 743 and 744, which show two instances in which premature loss of deciduous second molars resulted

in malocclusion, one shown during the growth of the denture and the other at maturity.

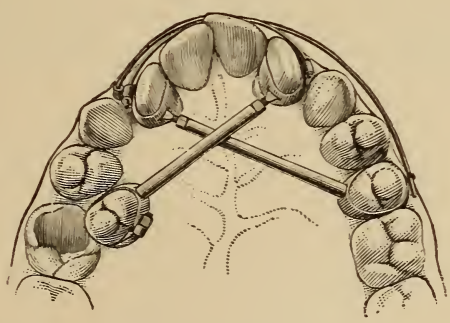
Another point of interest in connection with this subject is that this displacement mesially may, and often does, result in the mal-locking of the lower first molars with the upper, and in this way becomes the prime cause of the establishment of the subdivision, or, if on both sides, the full second division of Class II.

FIG. 743



While probably the greatest harm results from the premature loss of the second deciduous molar or canine in either arch, the principle applies to the loss of any of the deciduous teeth, the difference being only in degree.

FIG. 744



The mechanical influence of the deciduous teeth in the development of the dental arches is so important that they should not only by all means be retained their full normal period, but, if they become affected by caries, their full mesio-distal diameters should be restored by suitable fillings after sufficient separation. Likewise, if a deciduous tooth be

lost through the premature absorption of its root, the full space occupied by it should be maintained by some suitable retaining device.

Prolonged Retention of Deciduous Teeth.—One or more of the deciduous teeth are occasionally retained beyond the normal period. In this event the succeeding tooth will either be prevented from erupting or will be deflected to a malposition.

Loss of Permanent Teeth.—What has already been stated in regard to the mechanical influence of the deciduous teeth in assisting the normal development of the dental arches and promotion of harmony of the facial lines is equally applicable to the permanent teeth up to the period of their full eruption, or until the last of the molars has taken its position. This is a point of such importance that it should be carefully considered by all students of occlusion. If one or more of the permanent teeth anterior to erupting molars be extracted, the wedging process, so necessary in developing the arch, serves only to close the space thus made, and there will be no carrying forward of the teeth and process. The evil effects already enumerated as arising from unequal development of the two arches will follow. It should also be borne in mind that the interdependence of the teeth is so great at all times that the loss of one or more at any period in their history must have a marked influence on the remaining teeth. Especially is this true of the loss of the lower first permanent molars. (See page 830.)

Tardy Eruption of Permanent Teeth.—It occasionally happens that a tooth, with or without apparent cause, fails to erupt, and remains embedded in the alveolar process for months, or even years. Usually the space is partially or wholly closed by the adjoining teeth. The impaction of the canine is the most common of any of the teeth, owing to the fact that it erupts after both its mesial and distal associates, and must in all cases meet more or less resistance from them. If, later, efforts toward eruption occur, the tooth must necessarily be deflected, or force other teeth into malposition.

Supernumerary Teeth.—Supernumerary teeth, as their name implies, are anomalies, or extra teeth above the normal number of thirty-two. In outline they rarely resemble any of the typical tooth forms, being most commonly peg-shaped or conical. Although they may erupt in any part of the dental arches, or even nearly cover the entire vault of the upper arch, as shown in a model in the writer's collection, and also in two or three other well-known cases, their favorite location is between the central incisors, in the region of the laterals, or in the bucco-embrasial spaces between the molars. The reason for their appearance is not clearly established.

Habits.—The habit of sucking the thumb, lip, or tongue, or that modern and highly pernicious instrument known as a "pacifier," so frequently formed by young children, will not only cause malocclusion of the deciduous teeth, but may and often does so pervert the functions

of the lips or tongue as to ultimately lead to marked malocclusion of the permanent teeth.

The pernicious habit of biting the lower lip, or pressing the occlusal edges of the upper teeth against its outer surface, has a tendency to move the upper centrals forward, thus lessening their natural resistance to the narrowing of the lateral halves of the arch.

This habit is very common, is often extremely difficult to overcome, and probably accounts for many ultimate failures in orthodontic treatment. It is always a marked accompaniment of cases belonging to Division 1 of Class II and its subdivision, and unless it be overcome and the normal functions of the lips regained, the incisors cannot be kept in their normal positions.

Another habit, although more rare, that of resting the tongue between the upper and lower incisors, produces the effect shown in Fig. 745.

FIG. 745



The pressure upon the incisal edges prevents full eruption and holds the teeth in infra-occlusion, while the molars, being held apart much of the time, lengthen into positions of supra-occlusion from lack of resistance.

Disuse.—The structure and history of the jaws and teeth show that they were intended for much use. There can be little doubt that the modern methods of food preparation tend to such disuse of the jaws and teeth as to have a marked general effect in causing malocclusion.

Abnormal Frenum Labiorum.—A somewhat common form of malocclusion is distinguished by a space between the upper central incisors, and occasionally, although very rarely, between the lower centrals. This space varies in width from one to four and even five millimeters, always

presenting an unpleasing appearance and interfering with speech in proportion to its width. The cause of the deformity is abnormal development and attachment of the *frenum labiorum*, which, instead of being normal in size and ending in its attachment to the gum about five millimeters above the gingiva, not only reaches the gingiva, but passes directly between the teeth and is attached to the likewise overdeveloped mesio-lingual tuft. This strong fibrous ligament keeps the teeth separated by its mechanical action.

There are other causes of malocclusion, many of which are not clearly understood, and their discussion here would be unfruitful. One which has claimed much prominence in the past is heredity. It is now, however, believed that heredity plays an unimportant part in the production of malocclusion, and that most of the causes are mechanical and operative subsequent to birth.

ALVEOLAR PROCESS AND PERIDENTAL MEMBRANE

The importance of a thorough knowledge of the alveolar process and peridental membrane is perhaps greater in orthodontia than in any other branch of dentistry, for to the orthodontist these tissues are secondary only in importance to the teeth themselves; and it is largely owing to our intelligent comprehension and handling of these tissues that we are enabled to successfully correct malpositions of the teeth. It is unnecessary to here enter into an extended discussion of these structures.

No thoughtful person can study the arrangement of the fibers of the peridental membrane without being impressed with their wonderful perfection of adaptation for resisting the various tooth movements incident to occlusion and mastication, and a knowledge of this arrangement is of peculiar interest to the orthodontist, enabling him to better comprehend not only the amount of force required and difficulties to be overcome in moving teeth, but the necessary anchorage to be gained from teeth in performing the operation, as well as a far better insight into problems of retention.

Tissue Changes Incident to Tooth Movement.—When the proper amount of force is exerted upon the teeth to be moved, "the bending of the process, and the absorption of bone, principally of the cancellous structure between the external and internal plates,"[1] occurs.

In youth, or before the bone has become dense, it permits of much bending, so that incisors may be moved out of inlock in a few hours, or the lateral halves of the arch may be widened in a very few days. This is easily explained when we remember the cancellous structure of

[1] Dr. F. B. Noyes.

the bone, the inelasticity of the fibers of the peridental membrane, and their very strong attachment to it.

While more or less springing of the bone is probably always an accompaniment of tooth movement, yet in proportion as the bone becomes dense with age, so the modification of the process attendant upon tooth movement changes from springing to the slower action of absorption and the still more slow deposition of bone.

Coincident with the changes in the bone there are also pronounced changes taking place in the peridental membrane. As force is exerted on the moving tooth the membrane is compressed in front of it, between it and the wall of the socket, while a greater tension of the fibers of the membrane takes place on the opposite side. As a result of this tension and compression the nerves of the membrane are impinged upon, causing a greater or less sense of pain, which, as a result of the slight movement of the tooth and temporary paralysis of the nerves from pressure, subsides more or less quickly according to the amount of inflammation present.

As a result of this pressure the absorbent cells, or osteoclasts, are stimulated to increase in number and activity. They immediately engage in the absorption of the portion of bone most involved in the movement, as well as of the bone attachments of the fibers on greatest tension.

While these changes are taking place the osteoblasts have become active, and have begun filling up the depression and reattaching the fibers by the redeposition of bone. But as this is a much slower process than that of absorption, the tooth is found to be more or less loose in its socket at the completion of its movement, as well as long after, necessitating its being supported by means of the retaining devices until the deposition of bone shall be complete and the socket modified for its support in its new position.

If a tooth be elevated in its socket, the principal change involves the peridental membrane. The fibers at the end directly resisting this movement are severed, and the oblique or suspensory fibers are stretched and recurved upon themselves. The result of the partial withdrawal of the conical root is increased space, not only at the end, but also on the sides of the root, so that there is considerable freedom of movement of the tooth, necessitating the deposition of bone over the entire surface of its socket, as well as increase of height of margin and a reorganization of the entire system of fibers. This explains the necessity for such protracted suspensory retention, and the comparative ease with which the movement of elevation may be performed.

In the movement of depression—the most difficult tooth movement —the bone must be absorbed by the osteoclasts over the entire surface of the alveolus to allow for the advance of the root of conical form. The fibers of lateral support are stretched, while the suspensory fibers

are also stretched, and severed at their points of attachment to the bone, thereby necessitating more disturbance of tissues and requiring more force and time than any other of the seven movements.

In the rotation of a tooth, as probably most of the fibers indirectly tend to prevent the tooth from turning in its socket, and, in addition, there are an unusual number at the four angles so arranged as to directly resist such action, much absorption of the fibers, as well as much absorption and bending of the bone are necessary, which easily accounts for the greater amount of time and force required to perform this movement.

In all cases of tooth movement a large number of the fibers of the membrane, as well as the bone, remain on tension long after the movement is complete, the force they exert tending to draw the tooth back to its original position, thus necessitating considerable support from the retaining devices until these tissues, as well as the muscles, have become thoroughly reëstablished in harmony with the tooth in its new position.

In accomplishing the movement of teeth lingually, labially (or buccally), mesially or distally, the principal change is in the position of the crown of the tooth, it being tipped into its correct position. The usual supposition is that the tooth in the alveolar process acts as a lever, the crown, or long end of the lever, moving in one direction, and the apex of the root in the opposite direction. To make clear these supposed changes, and especially the extent of the movement of the apex, writers have frequently used the illustration of a post driven about two-thirds its length into the earth. If force be exerted at right angles to a side of the post near its top, the post will act as a lever in the displacement of the soil, the two ends of the lever moving in opposite directions, and the pivotal point being somewhere near the beginning of the last third of the embedded portion.

The illustration is a poor one and very misleading, as the mechanical conditions are very different. Doubtless this would be the result if the tooth, like the post, had but one resistant substance and that equally distributed in all directions about its root; but, as is shown by a study of the alveolar process, the bone varies greatly in thickness over different portions of the root and in different teeth, so the amount of displacement of the apex of the root of a tooth depends, frequently, upon the location and the movement of the tooth, and whether one tooth or a number in the same region are being moved in the same direction. In reality there may be little or no displacement of the apex, or there may be considerable.

In the first place, the alveolar process is not a level plane, like that in which the post is implanted, but a projection or high ridge, of elastic structure, and admits of some bending laterally, its susceptibility to this action increasing proportionately as we approach the top. The pronounced bending of the process is a matter of common observation in efforts at extraction.

Again, the mechanical difference in the attachment of the post to the soil and the tooth to the alveolar process is such as to still further add greatly to the difference in the results of their respective movements. As the apex of the root is implanted deeply in the bone, which is greatly thickened in its lingual direction and reinforced by the strong cortical layer of the alveolar process, its movement lingually could not well take place as a result of springing. This movement is further strongly resisted by the innumerable inelastic fibers that encapsule the apex, radiating in all directions for its firmest possible attachment to the bone, their ends being enclosed in its structure.

So in the labial movement of the crown, the lingual movement of the apex of the root is not only resisted by the bone in front, but also behind and on each side, by reason of its attachment, while with the end of the post little, if any, resistance is offered by the soil behind or on either side, but only by that in front.

Another difference. The force for the movement of the post is applied remote from the fulcrum, while the force exerted on the tooth by the ligature is applied close to the fulcrum, or at a point best calculated to facilitate the bending of the alveolar process in the labial direction.

Again, unlike the post, several teeth may be associated in the movement, which adds still further to the probabilities of the labial, as well as adding correspondingly to the improbabilities of the lingual movement of their apices.

In the movement buccally of the upper molars there is bending or absorption of the outer plate, the palatal roots are elevated in their sockets to make easier the tipping of the crown, with probably no movement at the apices of the buccal roots, unless it be that they are forced deeper into their sockets. In the lingual movement of the same teeth there is more or less bending of the process, the forcing deeper into its socket of the palatal root, with perhaps some elevation in their sockets of the buccal roots.

In the same movements of the lower molars there is greater displacement of the apices of the roots in the opposite direction from which the crowns are moved, owing to the great thickness of the buccal plate of the alveolar process.

In the movement of teeth mesially or distally the bending of the bone must be less, the movement of the teeth more nearly resembling the movement of the post, the apex moving slightly in the opposite direction from the crown, as in Fig. 801.

The Pulp.—While the pulp of the tooth is a tissue more or less involved in tooth movement, when the operation is properly performed this tissue is practically undisturbed and should suffer no real injury. On the other hand, its normal function may be so interfered with as to cause it to suffer marked disturbance and even complete devitalization,

especially if the movement be conducted too rapidly, or the force be too abruptly applied. With modern regulating appliances, however, the most perfect control of the force for the movement of teeth is now easily possible, so that other than very slight inflammation is inexcusable.

It is often desirable to perform tooth movement soon after the eruption of the teeth, or before the root is fully formed, the end of the root then having a broad, funnel-shaped opening. If the movement be intelligently performed, the pulp at this age should suffer no greater disturbance than when the root is fully calcified.

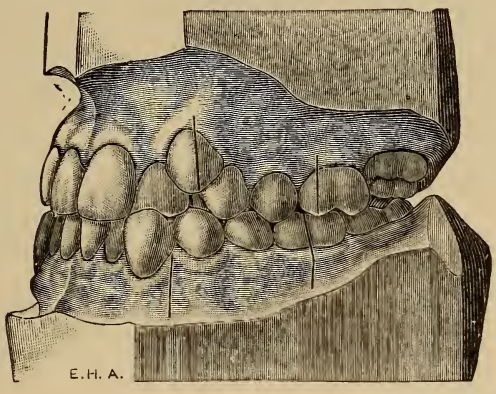
Physiological Changes Subsequent to Tooth Movement.—Important physiological changes in the tissues involved also occur subsequent to tooth movement. To better understand these changes we must keep in mind the conditions previously existing. The development of malocclusion is gradual, and, in proportion as the positions of the teeth deviate from the normal, a corresponding deviation is necessitated in the development of the alveolar process, and, to a greater or less degree, in the bones of the jaws, vault of the arch, the nasal tract, and the muscles of the face. All being out of harmony, the tendency is usually to favor still greater inharmony, or departure from the normal, as growth and development progress.

After the crowns of the teeth have been moved into correct positions in the line of occlusion and harmony of the occlusal planes has been established, the positions of the teeth and function of the occlusal planes have been so changed as to exert a different influence upon the bones and muscles. The tendency of the forces now is to stimulate nature to efforts toward the rearrangement of these tissues and their normal growth and development, in accordance with the demands of the teeth in their new positions and with her original design. Evidences are common throughout surgery of nature's wonderful inherent power to remedy her defects, and of her prompt response as soon as favorable conditions for self-assertion have been established. The natural changes following the correction of malocclusion are often pronounced and gratifying.

The cognizance of the possibilities of these changes should in many instances modify our plan of treatment from what it would be were we ignorant of them. Very frequently where there has been change of position of a number of teeth, especially in both arches, some may occupy planes of greater elevation than others, or the cusps of some may not occupy exactly normal mesio-distal relations; but if we have succeeded in placing the teeth so that the inclined planes of their occlusal surfaces favor their normal positions, their proper heights and relations will gradually become established as a result of occlusion. In some cases the incisors may apparently be much too short, but after a few weeks or months, when the posterior teeth shall have become settled in their new positions, the length of overbite of incisors will be normal.

Another noticeable and most important change following tooth movement is the growth of the alveolar process, as well as that of the co-related bones, muscles, and tissues which have been arrested in their growth as a result of malocclusion and the perversion of the function of the teeth. This is illustrated in the following case of historical interest,

Fig. 746



Figs. 746 and 747, where the pronounced arrest of these tissues is noted, especially that of the alveolar process in the region of the roots of the upper incisors and vault of the arch.

After the arch had been enlarged and the crowns of the incisors carried forward, the positions of the teeth are shown in Fig. 748, which

Fig. 747



marks the beginning of the period of retention. But it will be noted that the incisors stand at a very pronounced angle of inclination, with the deep depression over the apices of the roots of the incisors more pronounced.

After faithful mechanical retention for nearly three years, a gratifying discovery was made, which is noted in Figs. 749 and 750, namely, the complete normal development of the alveolar process and the shifting forward of the apices of the roots of the incisors until these teeth stood

Fig. 748

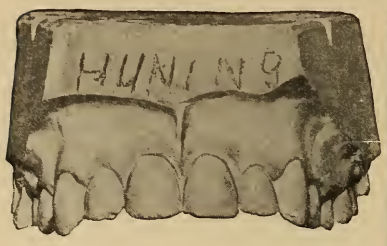
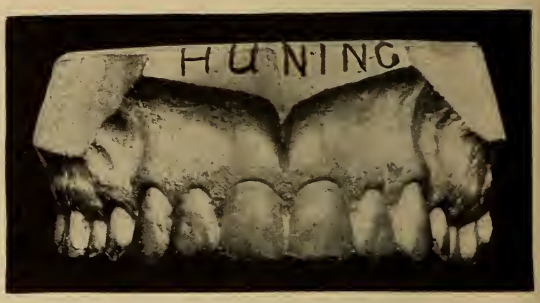


Fig. 749



in their normal upright positions. The vault of the arch has been remodelled, the floor of the nose widened, and probably the maxillary and co-related bones and tissues have been greatly modified toward the normal in development.

This was, indeed, a gratifying discovery to the writer,[1] for he realized that it was the fulfilment of a physiological law of growth following the

Fig. 750



establishment of normal occlusion and normal function of the teeth. He has since verified this in a large number of other cases, many of which were much more pronounced in the arrest in their development than

[1] Angle, Malocclusion of the Teeth, 7th edition.

this case. It is now standard practice and there can no longer be any excuse for the extraction of teeth in these cases, founded on the time-honored supposition of the old-school practitioners that the jaws are too small for the teeth.

Other cases verifying this law will be shown in the section on Treatment.

It is well to remember that this subsequent development is very active and quick to respond in youth, or during the period of eruption of the incisors and for some years later, but that it diminishes in activity in proportion to the age of the patient—another strong evidence of the importance of early treatment of malocclusion.

That the bone cells may be stimulated and more rapid and complete development effected in these cases by mechanical means is now proved.

That the most favorable tissue changes possible may follow tooth movement it is, of course, of the utmost importance in all cases that all pathological conditions of the throat and nose receive the most careful attention from the skilful rhinologist.

MODELS

The first step in the study of all cases preparatory to treatment is the taking of accurate impressions of the teeth, from which accurate, articulating models of both arches are made. Such models not only assist in the classification and diagnosis of cases, but also aid in determining the proper plan of treatment, and are also exceedingly valuable for reference during its continuation, for by comparing the models with the natural teeth at each visit of the patient we may not only keep positively informed as to the exact movements of the malposed teeth, but any unfavorable movement of the anchor teeth may also be immediately detected.

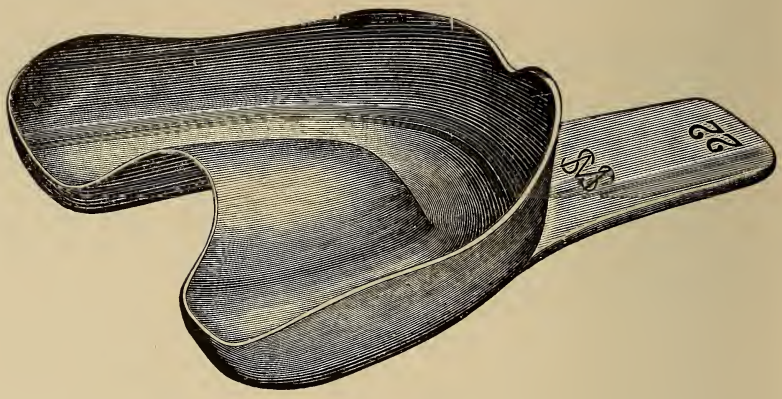
Material for Impressions.—Models are only valuable in proportion as they are accurate, and the only models approximating accuracy are those made from plaster impressions. These models must show not only both arches and the relative positions of the teeth and cusps, as well as the vault of the arch, rugæ, and gums, but must also correctly show as much of the roots and their positions as are indicated by the gums and alveolar process up to the point where the attachment of the muscles renders obscure the further shape of the jaw.

Models sufficiently perfect cannot be made from impressions taken in modelling compound or other of the plastics.

The shape of the jaw, together with the shapes and inclinations of the teeth, make the removal of a plastic impression, without change of form, impossible. The degree to which arrest of development of the

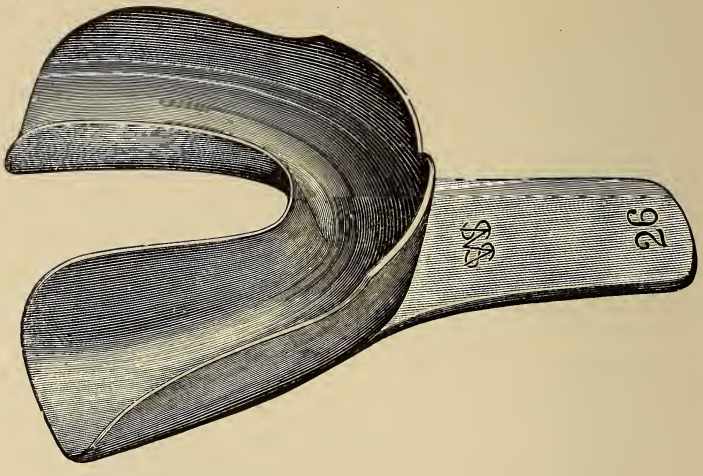
alveolar process has taken place, especially in the region of the roots of the incisors, so important to accurately record in the model, can only be the merest supposition in a model made from a plastic impression.

Fig. 751



When the correct method of taking plaster impressions has been learned the operation occasions but little, if any, more trouble to the operator, or objection from patients, than if one of the plastics were used.

Fig. 752



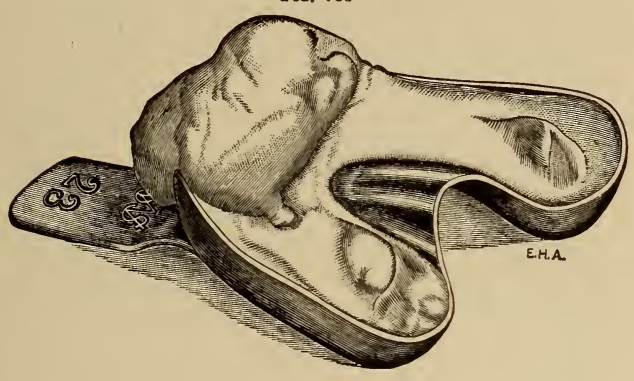
The Trays.—The writer's trays, shown in Figs. 751 and 752, are best suited, being much higher than the ordinary trays. In taking an impression a sufficiently large tray should be selected, which should, if necessary, be bent to conform more nearly to any peculiarity in the shape of the jaw; this will not injure the tray.

Taking the Impressions.—Good impression plaster is mixed in the usual way and carefully distributed, as shown in Fig. 753, the shape

and height of the trays making but little impression material necessary. It will be observed that the greater amount is placed in the anterior part of the tray and made to extend over the outer edge of the rim, none being allowed in the vault of the tray.

It is now placed squarely in position and the plaster allowed to rest evenly in contact with the occlusal edges of all the teeth, but not forced up into position. The lip is then raised, and the plaster extending outside of the rim of the tray is carried high up underneath it with the finger. This is to insure the expulsion of air, as well as a high impression. The tray is then forced up evenly until the points of the teeth touch the bottom of the tray, and steadily supported upon the end of the index finger only. To expel the air from the cheeks they are now gently manipulated, but not drawn down, as to do this would force down a portion of the plaster and prevent one of the important objects—viz., a very high impression.

FIG. 753



It should be allowed to remain in position until the plaster has become thoroughly set, which is very important, as the harder the plaster is allowed to become, the sharper will be the impression.

The tray is now loosened and taken away, leaving the impression in the mouth. It is essential that the tray should loosen easily from the impression; hence the importance of its being kept clean, bright, and smooth.

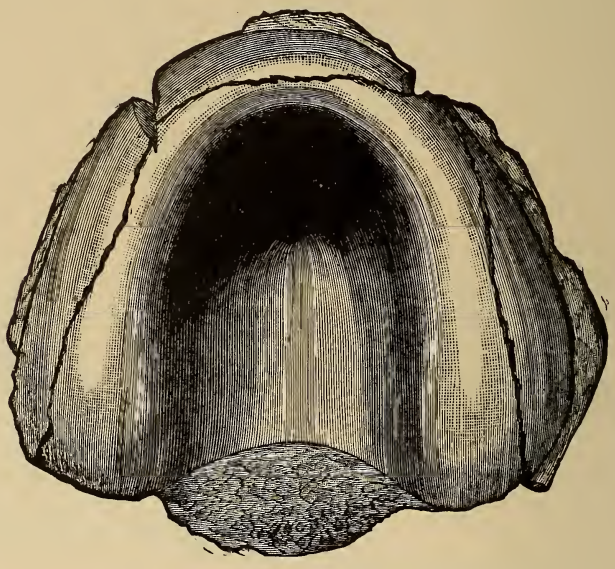
Two grooves are then scraped or cut in the hardened plaster on a line parallel with the canine teeth, but not cut quite through. Then with a quick pry with the point of a knife the anterior plate is loosened. The lateral pieces are then broken off with the thumb and finger, when the large piece covering the roof of the mouth alone will remain. This may be readily worked loose, and if the operation has been carefully performed the impression will consist of four pieces, although to have a much greater number would in no way injure it.

After the pieces of the impression are dry they are united by means of wax, and should present the appearance illustrated in Fig. 754.

This method of taking impressions preserves the fine points of the interdental spaces. We believe it to be the only practicable way of taking an accurate impression.

In like manner the impression of the lower arch is taken, removed, and united, being careful to observe the essential points, namely, carrying the impression material, which has been built up and outside of the anterior part of the rim of the tray, well down beneath the lip with the

Fig. 754



finger, and after forcing the tray home the excess plaster on the sides is carried back and down to avoid folds in the cheek, while the tray is steadily held by the ends of two fingers of the left hand, one to rest on the top of each lateral half.

Varnishing the Impression.—The impressions being united, they should be coated very evenly with shellac varnish. At the expiration of half an hour, or when the varnish has become hard, a second coat should be applied over the occlusal surfaces of the teeth and rough points only, not over the smooth surfaces, especially the labial gum surfaces. Dry again, and then apply over the entire impression a very thin, even coat of sandarac varnish.[1]

[1] It is important that both of these varnishes shall be of the proper consistence, which is difficult to describe. If too thin, the hard, glossy surface will be wanting, and it will be difficult to separate the impression without injury to the model. If too thick, all fine tracings of the impression will be obliterated.

The Models.—After drying for half an hour the impression will be ready for filling, which may be best accomplished, in order to insure expulsion of air bubbles, by quickly and carefully painting the plaster into the tooth cavities with a small camel's-hair brush, then rapidly filling with a spatula, gently shaking for a while (never jarring), after which it should be turned bottom upward on a glass slab and allowed to thoroughly set.

Numerous horizontal and vertical grooves are then made in the impression (Fig. 755) and it is also shaved thin over the occlusal surfaces of the teeth, to expedite the separation of impression and model. Should any air cavities be found in the model, they may be remedied by the use of a delicate brush in the artistic application of plaster of a creamy consistence. A cusp or broken tooth may in like manner be repaired.

Fig. 755



The models may now be trimmed, and not only will there be a surface as smooth as polished marble, but each cusp, all the interdental spaces, and the rugæ, as well as the inclinations of the roots, and even the minute "stipples" of the gum, and the developmental lines of the enamel, will be accurately and beautifully shown. Any coating of paint or varnish only detracts from the beauty of such models.

The models should be trimmed according to lines of graceful proportions and artistic balance, which is made much easier by the use of the model plane and combination square, shown in Fig. 756.

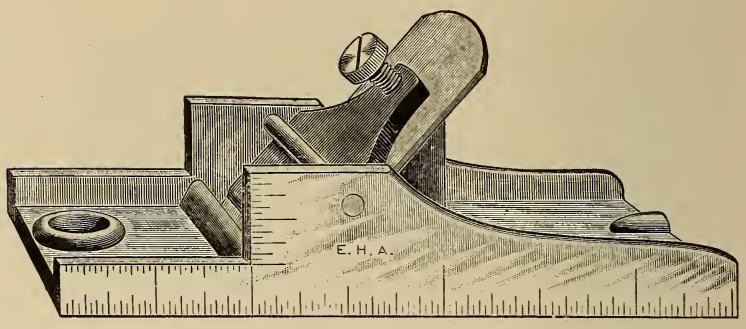
After they are trimmed, the models should be carefully compared with the natural teeth, and the occlusal relations indicated by two or more pencil markings, so that the proper points of contact may afterward be readily found. These serve the purpose much better than any form of an articulator.

As soon as the teeth have been completely moved, another impression should be taken and models made. This is done after all appliances have been removed and the teeth thoroughly cleansed, and immediately previous to adjusting the retaining devices. These models are invaluable for comparison with the natural teeth during the period of retention, as well as for future reference.[1]

A collection of fine, accurate models is not only an incentive to keener interest and better work, but is a most valuable form of "library" in itself, in which much that is instructive and interesting is recorded that can never be reduced to writing.

Models should never be mutilated by the fitting of bands and appliances. While they may serve as a basis for general measurements for the appliances, the fitting can only be properly done on the natural teeth.

Fig. 756



Model plane.

Photographs.—Quite as important as models are good photographs of the patients' faces, in which are represented full profile and front views in a simple, natural pose. These are far preferable and more reliable in judging the harmony and inharmony of the patient's face than is a plaster cast of the face.

Röntgenographs.—Röntgenographs, now so easily and quickly made, are often of great value in settling all doubts as to whether teeth be missing or their exact locations and forms if merely embedded. While these points may be determined in the majority of cases by careful inspection of the contour of the alveolar process, and digital pressure, together with the use of the exploring needle, yet when any doubt exists the röntgenograph should be resorted to. Fig. 757 illustrates a case as revealed by the röntgenograph, where the canine is so deeply embedded in the alveolar process as to baffle the ordinary methods of diagnosis.

[1] For a more complete study of the writer's method of impression taking and model making the reader is strongly recommended to a most thorough treatise in booklet form on this subject, by Dr. Jos. Grünberg, of Berlin, for sale by the S. S. White Dental Mfg. Co.

Fig. 758 shows the rare case of a missing permanent canine, and the absorption of the root of the deciduous canine. The first premolar is about to erupt.

FIG. 757



FIG. 758



REGULATING APPLIANCES

Two plans are now followed in the designing and constructing of regulating appliances, the first based upon the belief that each case so radically differs from all other cases that an appliance must be invented and constructed from raw material to meet its special requirements. The second plan recognizes the division of malocclusion into a few clearly defined classes, having requirements of treatment clearly indicated, with fixed, standard forms of ready-made regulating appliances acting upon definite principles, which amply provide for the requirements of all cases belonging to each class.

The first, until the introduction of the writer's appliances, was the universal plan, having come down to us from the earliest history of orthodontia; indeed, much of the literature of the science consists of descriptions of appliances which have been invented to accomplish tooth movements in special cases, until some thousands are recorded, one author alone boasting of many hundreds. When something may be accomplished in the following of this plan, it should require no argument to prove that there are many reasons why it is most defective and unscientific.

First, it necessitates that each dentist shall be an inventor, and it is well known that the inventive faculty is rather a natural gift than an acquirement, and that it can be exercised successfully only by a very few. Then, as all inventions if perfected must be experimented with, it must follow that each case so treated must be largely in the nature of an experiment, often necessitating many changes in the plan and

construction of appliances. Hence all treatment upon such theory must be, and, in fact, has ever been, tedious and costly, with a large percentage of failures.

Secondly, another objection in following this plan is that the construction of appliances must necessarily be more or less crude and lacking in requisite proportions, for any instrument only reaches perfection as to size, proportion, temper, strength, and finish after much experimenting and repeated efforts toward perfection in manufacture.

Finally, another objection more serious than all is that as the plan is empirical, with only a vague and indefinite basis from which to reason, the difficulties in teaching and practice become very great and the results greatly limited. After a life of practice the dentist following this plan must still be in a maze of experiments, and unable to impart much information that could be of assistance to those who may begin practice after him.

The second plan, as we have already stated, recognizes the practicability of fixed, standard forms of devices for the requirements of tooth movement necessary in all the various classes of malocclusion, the proper forms having been arrived at as a result of careful experimentation and close observation in a very large number of cases embracing the greatest variety of malocclusion. Instead of hand-made productions by the dentist, which, with his limited experience and meager facilities, must always fall far short of the ideal, they are, like fine watches, made upon elaborate machinery by the most skilful workmen.

If such appliances are practicable, it must at once become apparent that the advantages from their use must be very great, for, instead of being confronted with a confusing and almost limitless number of devices, which can at best only serve as general, vague, and often delusive patterns to him, the student has but to thoroughly familiarize himself with a few standard devices which he may quickly and easily apply.

Again, familiarity with and repeated use of standard appliances add greatly to the possibilities of development of skill and judgment in their use, as in the case of the frequent use of favorite patterns of pluggers or excavators which have also been made by skilled experts. And whether or not ideal standard regulating appliances have yet been reached, the possibilities and positive advantages of the principle over that of the first plan are so marked that we think all teachers who are interested in this branch should make effort toward that direction, rather than to assist in perpetuating a principle so obviously defective that it must be apparent to all that it is a positive hindrance to the real progress of orthodontia.

It is now well known that most of the real progress in dentistry and surgery, and, we may add, in orthodontia, has been made since the dentist, surgeon, and orthodontist were relieved of this impractical task by experts who have produced instruments so perfect in design,

construction, and finish as to be often in advance of the comprehension and skill of those who are to use them.

Materials for Construction.—A large number of materials have been used in the construction of devices for the regulation of teeth. Gold, silver, platinum, platinous gold, platinous silver, iridioplatinum, platinoid, aluminum, nickel silver, brass, copper, aluminum bronze, steel, iron, vulcanized rubber, India rubber, wood, silk, hemp, gut, and many combinations of these materials have all been used. None are ideal, yet most of them possess properties of more or less value. After years of experimenting the writer is convinced that the material most nearly filling all requirements is high grade nickel silver.[1]

Since its introduction by the writer, in 1887,[2] for the construction of regulating appliances, it has largely supplanted all other metals for this purpose. Owing to its excellent qualities, as well as its inexpensiveness, nickel silver has been an important factor in the remarkable progress that orthodontia has made in recent years. Its great practical value becomes more and more apparent with familiarity in its use. It is very susceptible of skilful working, and may be developed to possess great strength and rigidity, or it may be given great elasticity, and when properly annealed it is very malleable. Rolled into a flat ribbon, it may be drawn by the band-forming pliers so tightly about a tooth as to conform to its surface with great accuracy, on account of its properties which permit of slight stretching, in striking contrast to gold or platinum, and even though it be but three-thousandths of an inch in thickness, it will be sufficiently rigid to withstand driving to place upon the tooth without crimping or changing form, if care be used.

Its surfaces are readily united by solder, and its fusing-point is so high that any of the various grades of gold or silver solder may be employed without injury to the band if only the requisite amount of heat be used.

It is so slow a conductor of heat that the excellent method of soldering by holding many of the pieces with the fingers may be employed,[3] again in sharp contrast to the other metals we have enumerated.

It is susceptible to a high degree of polish, which should always be given to plain bands after setting, and which is lasting in many mouths. Often these bands will assume a delicate bronze-like color, pleasing in appearance, and the writer has known of their being worn continuously for three years with no change of color. In a small percentage of mouths, however, they do become discolored, even to unsightliness. This fact has given rise to the only worthy prejudice we know of against the use of

[1] Nickel silver is an alloy of copper, nickel, and zinc, prepared in varying proportions, according to the use for which it is intended. The inferior grades contain iron and only a low percentage of nickel.

[2] Angle, Archives of Dentistry, 1888.

[3] Introduced by the writer in the first edition of his work entitled the Angle System of Regulation and Retention of the Teeth.

nickel silver for regulating appliances; but this objection is trivial in view of its many points of superiority and if the orthodontist will use the proper quality of nickel silver and obey the demands of modern prophylaxis, insisting on a reasonable degree of cleanliness on the part of the patient, and occasionally devoting a few moments of attention to the cleansing of appliances and teeth himself with the soft-rubber disk and pumice, as he should, no matter what metal is used for the appliances, there will be little occasion for complaint.

Another valuable property of nickel silver is that it is less liable to injure the enamel of teeth when worn in contact with it, than are any of the precious metals.

Notwithstanding the valuable qualities of nickel silver, the precious metals, as gold, platinum, and iridium, are still preferred by a few practitioners on account of their greater resistance to oxidation. Yet they are by no means free from this fault, as it is necessary to alloy them with base metals in order to gain the proper elasticity. Yet when properly alloyed they are sufficiently free from oxidation for the necessary use, and it is probable that in some mouths, for appearance' sake, they are more desirable than nickel silver, especially as retaining devices that are to be worn a long time upon the teeth.

THE WRITER'S APPLIANCES

When the writer first brought out his so-called system of appliances, malocclusion was yet unclassified, and the "special appliance for each case" method of treatment was the only one taught or practised. In an attempt to reduce to something like system and order the chaos of regulating appliances that cumbered the literature and hindered the progress of orthodontia, these appliances, designated as sets Nos. 1 and 2, with a few auxiliary parts, numbering some twenty in all, were introduced.

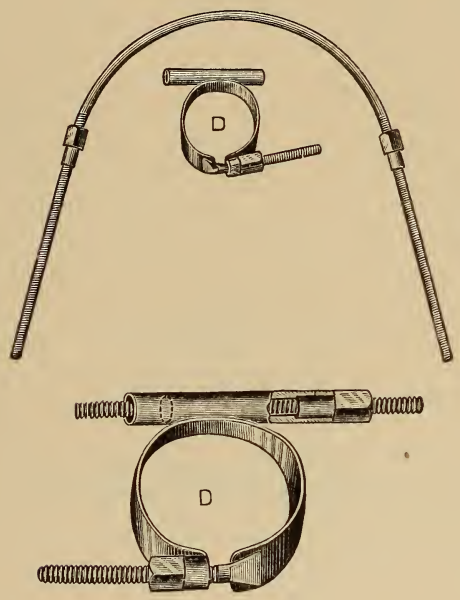
By their use separately and in combinations it was presumed, and truly, that tooth movements could be much more quickly and easily performed, and with far less annoyance to the patient, than by means of the necessarily crude, clumsy, and frequently very inadequate hand-made metal devices, or the far more undesirable and most unclean vulcanite plates, cribs, etc. With the greater development of the science, however, and especially since the classification of malocclusion, the writer has gradually dispensed with the greater part of even these few appliances, until at the present time he uses practically but one, or three modifications of a single principle. This principle was given us nearly two hundred years ago by the famous French dentist, Fauchard,[1] and it has since been used in many modified forms. It is now known as the

[1] Le Chirurgien Dentiste ou Traité des Dents, Paris, 1728.

expansion arch, and in conjunction with clamp-bands for the anchor teeth, and the auxiliaries of plain or spurred bands, and wire and rubber ligatures, it is adequate for all necessary movements of all teeth in each arch separately, as in Class I cases, or for the simultaneous movement of all teeth in both arches when used in connection with the Baker anchorage, as in cases belonging to Classes II and III.

The writer's improvements of this appliance may briefly be said to consist in change of metal (nickel silver), modification of form and proportions, delicacy of temper, greater length of threading of sides for universal adjustment of size, in the material, original patterns, and proportions of the anchor clamp-bands, and in the various attachments,

Fig. 759



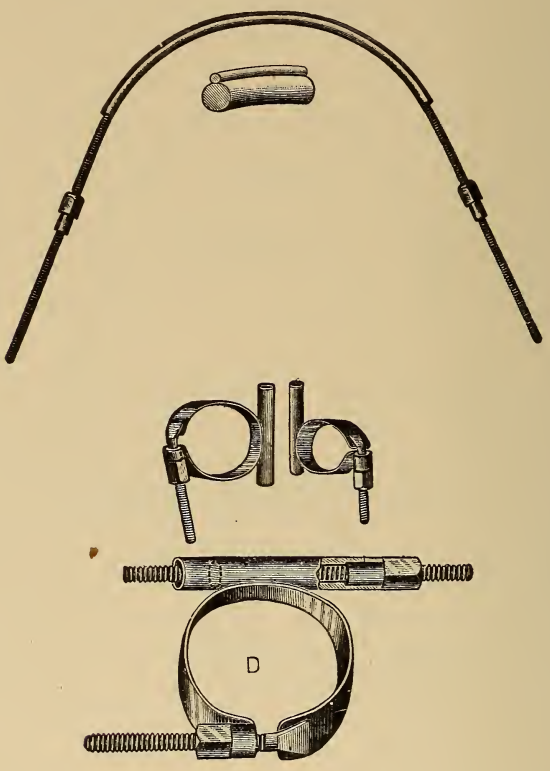
some of which are modified and others newly devised. Important among these is the addition to the clamp-bands of the long tubular sheaths for the reception of the ends of the arch, which not only protect the cheeks from abrasion by the threaded portion of the arch, but give greater stability to the anchorage. Still others deemed very important are the friction sleeve of the sheath of the clamp-bands and extension flange of the arch nuts, the extension rib on the ribbed arch, the sheath hooks, for use in the Baker anchorage, and last and most important, the brass-wire ligatures, descriptions of all of which follow, in connection with instructions for their use.

As before stated, there are three forms of the expansion arch. Fig. 759 represents the plain expansion arch *E*, which is a very elastic round

bar, bent to conform approximately to the shape of an ideal dental arch. The sides of this arch are threaded and provided with nuts, which, with the threaded portion of the arch, accurately fit the smooth-bore tubes of the X and D bands. One end of these nuts is elongated to form an extension flange, which accurately telescopes the friction sleeve of the sheaths of the D and X bands, as shown in the engraving.

This form of nut adds another truly valuable improvement to the expansion arch, as it enables us to make the exposed part of the nut very short and compact, at the same time giving greater length of thread

Fig. 760



and consequently greater strength. Its greatest value, however, is that this extension flange prevents the loosening of the nut by unscrewing from friction with the tongue or cheek—a common annoyance since screw devices have been used in the mouth, and for this purpose it is ideally simple and efficient. This improvement is also made use of in the writer's jack- and traction-screws.

Fig. 760 shows the ribbed expansion arch *E*, a later modification of the arch last shown, and differing from it only in that it is provided with a delicate rib on the periphery of the unthreaded portion, in which hook-like notches are to be made at desired points to prevent slipping of the

wire ligatures. By this means the direction of force on the moving teeth is accurately controlled. The rib also adds force to the arch for lateral expansion. It is a most important improvement.

Fig. 761

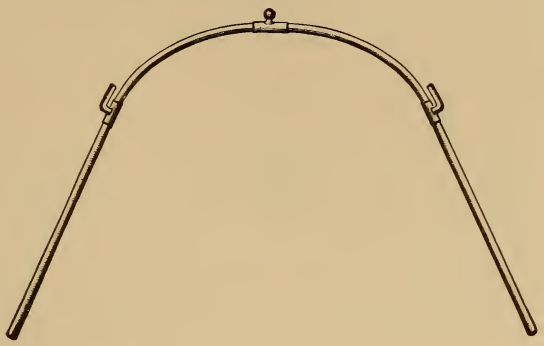


Fig. 761 shows the third form of the arch, as used by the writer, known as the arch *B*. It is a smooth, threadless arch, similar in form and temper to the plain expansion arch *E*, though more limited in use. It is especially designed for use in connection with the Baker anchorage, having a sheath-hook on each side for the reception of the rubber ligatures.

Fig. 762



These little sheath-hooks, Fig. 762, may also be obtained separately for attachment to either of the other arches whenever it may be desired to employ them in connection with the Baker anchorage.

Fig. 763



Fig. 763 represents six adjustable clamp-bands. Nos. 1 and 2 are plain, and are used both for tooth movement and in retention. Nos. 3 and 4 are provided with strong-headed pins soldered to their screw-heads. These were especially designed for the treatment of fractures of the maxillæ.[1]

[1] For a consideration of this subject the student is referred to the sixth edition of the writer's work on Malocclusion of the Teeth and Fractures of the Maxillæ.

The X and D bands are provided with smooth-bore tubes soldered to their sides, into which the ends of the arches and the extension flange of the nuts accurately fit. The X bands are for bicuspids and the D bands for molars.[1]

Fig. 764 shows three coils of band material from which plain bands for incisors, canines, or even premolars may be made, to serve as mediums

Fig. 764



of attachment to the arch through the wire ligatures. They also are very largely used in retaining devices. *C* and *F* are of the same width, being narrower than *H*, and *F* and *H* are of the same thickness, being thicker than *C*. *C* is used only when a very thin, delicate band is required. *F* is used where a stronger band is needed, and has much more universal use. *H* is used principally for canine bands.

Fig. 765

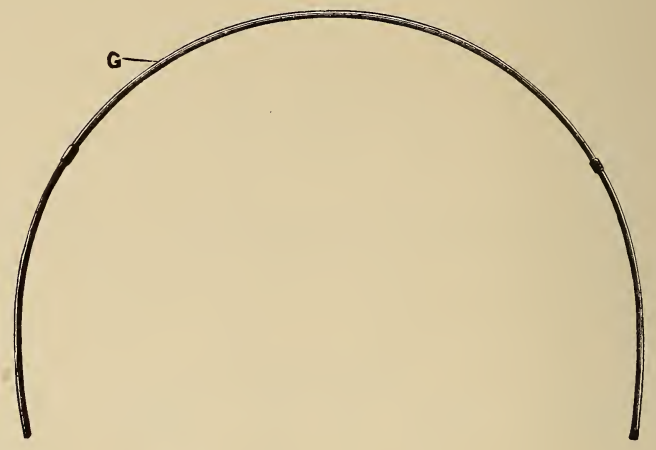


Fig. 765 represents the wire *G*, a section of very soft, smooth wire. For the making of spurs on bands for the attaching of ligatures, or for retention, it is indispensable. It is also used for reinforcing anchorage, and for the moving of teeth in a novel way, the latter being illustrated in Fig. 829. The size of this wire to be most universal of use was

[1] For the varying sizes of molar teeth are three sizes of D bands, although in the writer's practice the medium size alone meets nearly all requirements of the permanent molars. The smaller size, however, is occasionally demanded on deciduous molars.

decided upon, after much thought and experimenting, to be forty-two thousandths of an inch in diameter. Yet for the making of smaller spurs, and, occasionally, later forms of retaining devices, a wire of smaller diameter has proved advantageous. So the writer has recently added two smaller sizes, one twenty-nine thousandths of an inch in diameter and the other twenty-two thousandths of an inch in diameter. These are both of precious metal.

Fig. 766



Fig. 766 represents the retaining tubes *R*, which are used in detachable connections, in reinforcing anchorage, in retention, etc.

Fig. 767 represents the brass ligature wire, which is very soft, smooth, tough, strong, bright wire, especially prepared for the use of orthodontists. Three sizes meet all requirements.

Fig. 767

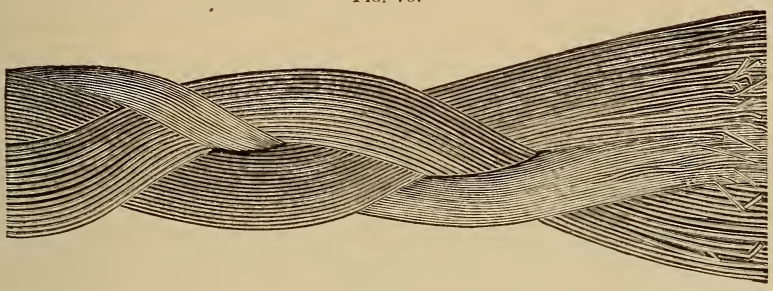
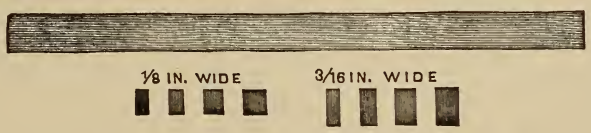


Fig. 768 represents strips of rubber used by stretching between tooth and arch, or between ligature and tooth, then cutting off the superfluous ends, as in Fig. 808. In this way force is made more continuous and the time for tooth movement shortened. In like manner the strips of rubber are used with great advantage to assist in rotating very obstinate

Fig. 768

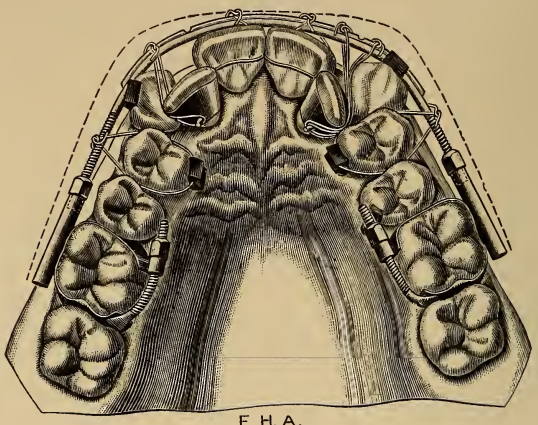


teeth, as shown in Fig. 769 and 770. The figures just referred to and Fig. 807 all show working combinations of the writer's appliances just described.

The following appliances are those which the writer has now practically eliminated from his practice, not because they were inefficient to

perform the tooth movements required of them, but because they were designed to act locally, so to speak, or only upon teeth that seemed

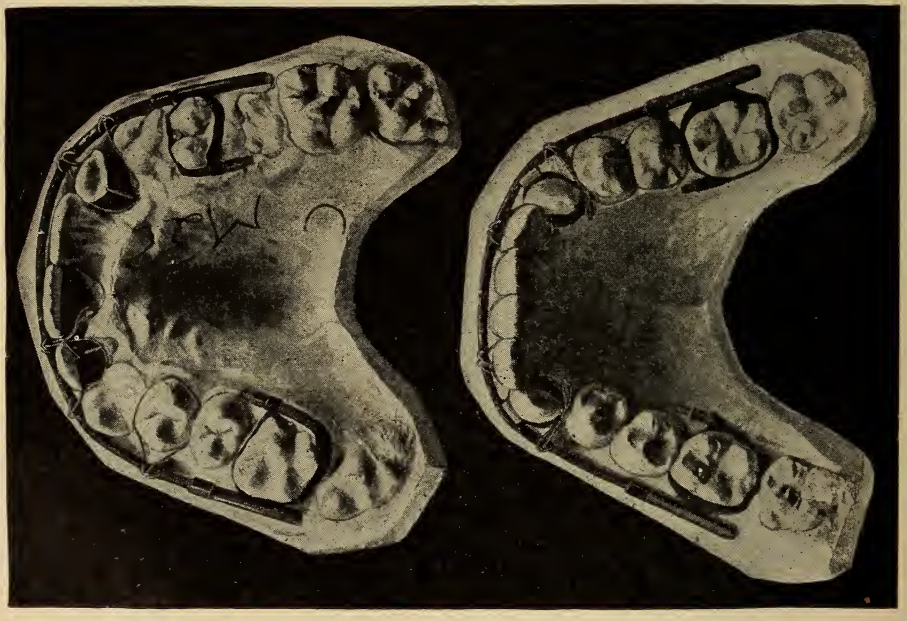
Fig. 769



E. H. A.

"crooked," instead of to operate from the basis of occlusion, and having control of one tooth or of all teeth in one or both arches. But, as will

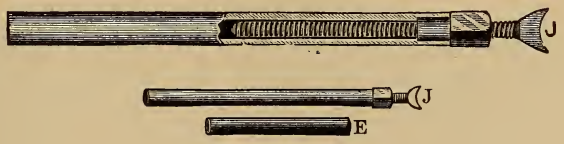
Fig. 770



be shown later, while not often used, they are still so necessary for some purposes that they cannot be wholly dispensed with. Their uses will be described later.

Fig. 771 shows the jack-screw *E* and *J*. The first regulating jack-screw was invented by Dr. Dwinelle, of New York, in 1848. This invention marked two important steps in the progress of this sciences (1) The introduction into orthodontia of one of the most compact yet

Fig. 771



powerful forms of mechanism known to mechanics for exerting force; (2) the beginning of fixed, standard forms of regulating appliances, with interchangeable parts, and kept in stock at the dental supply houses.[1]

Fig. 772



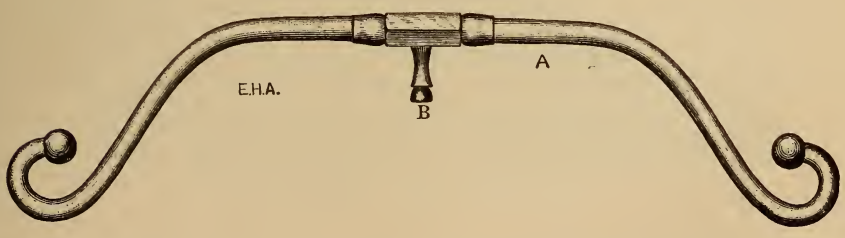
Fig. 772 shows the traction-screw *A* and *D*. It consists of a shaft bent sharply at right angles at one end, the other end threaded and provided with an extension flange nut and three accurately fitting tubes

Fig. 773



of smooth bore—one long one with friction sleeve for the accommodation of the extension flange of the nut, and two short ones, *D*. Since in treatment the sacrifice of teeth has become rarely necessary, the

Fig. 774



use for this once highly regarded appliance is greatly limited, yet it is still valuable on rare occasions.

[1] The writer's jack-screw was invented in 1886. Transactions Ninth International Medical Congress.

Fig. 773 shows a bundle of spring levers, of four different sizes. These are made of piano wire, on account of its superior elasticity; yet because of the liability of steel to corrode, no matter how heavily plated, its ordinary use is objectionable. These levers may also be made of nickel silver or of a combination of gold and iridioplatinum.

Fig. 775

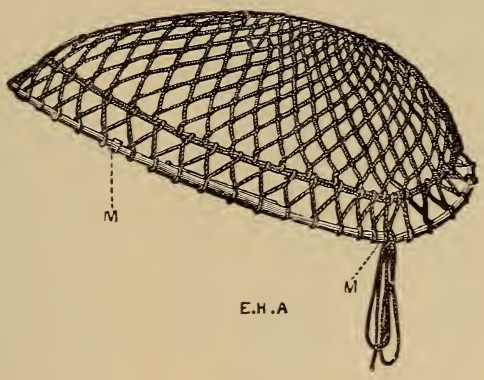


The traction bar *A*, Fig. 774, is provided with a standard in its centre, which has a socket for the reception of a delicate ball on the centre of the arch *B*. The hooked ends of this bar are for the reception of heavy elastic bands from the headgear, as shown in Fig. 775.

The headgear, Fig. 776, is a cap of silk netting laced to a metal rim and covering the back of the head, for the even distribution of force

exerted by the heavy elastic bands. This cap is strong, artistically made, and is very neat in appearance. The rim is non-collapsible and may be easily and quickly adjusted to fit any size of head.

Fig. 776



The traction bar and headgear still embrace the best principles in the application of occipital anchorage, but in their use the relinquishment and reapplication of pressure is necessarily frequent, and this is always an objectionable feature, being the most potent cause of inciting inflammation in tooth movement. So it is for the best of reasons that they

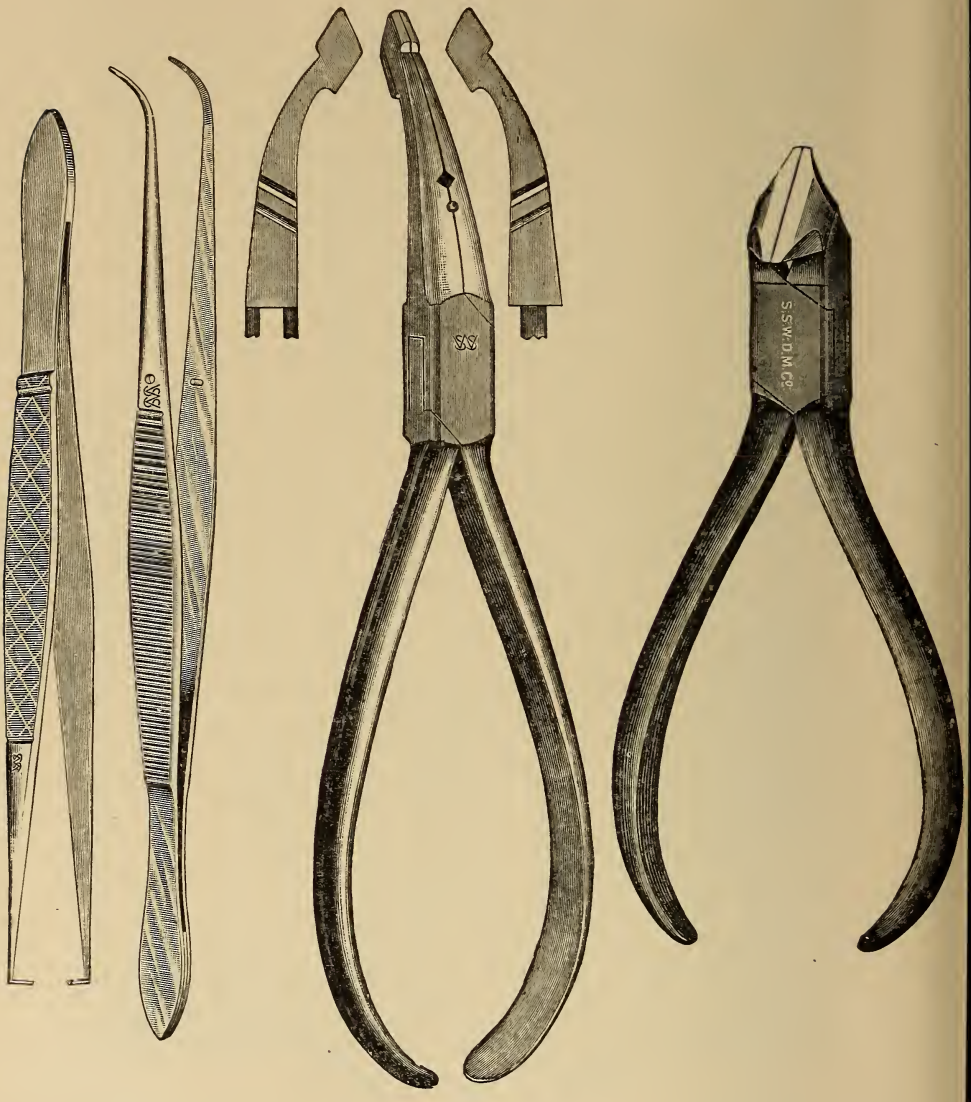
Fig. 777



have largely given place to the more rational method of applying force by means of the Baker anchorage. They cannot yet be wholly dispensed with, for it is occasionally very advantageous to apply force in this way as auxiliary to the Baker anchorage.

The chin retractor, Fig. 777, is made of aluminum; it is light, neat, and highly polished. It will fit in all cases, as it is only necessary that the fit be approximately accurate. A layer of fresh absorbent cotton should always be placed between metal and chin each time it is adjusted.

Fig. 778 Fig. 779 Fig. 780 Fig. 781



Used with the headgear, as shown in Fig. 777, it was formerly our chief reliance for the treatment of cases belonging to Class III, but its use, also, has been practically superseded by the Baker anchorage, yet it will doubtless continue to be a valuable auxiliary to the Baker anchorage in rare cases.

Tools.—For uniting the different parts of the appliances to form the various combinations, and for placing them in position upon the

Fig. 782

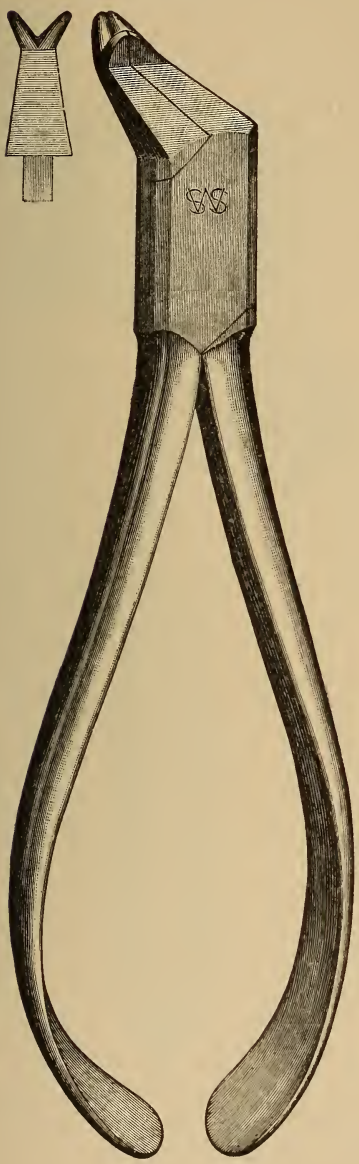


Fig. 783

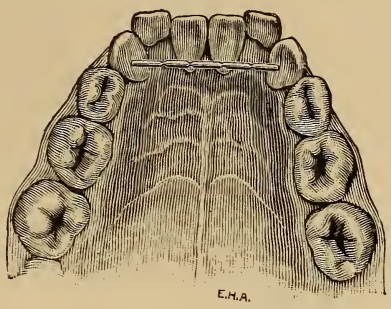
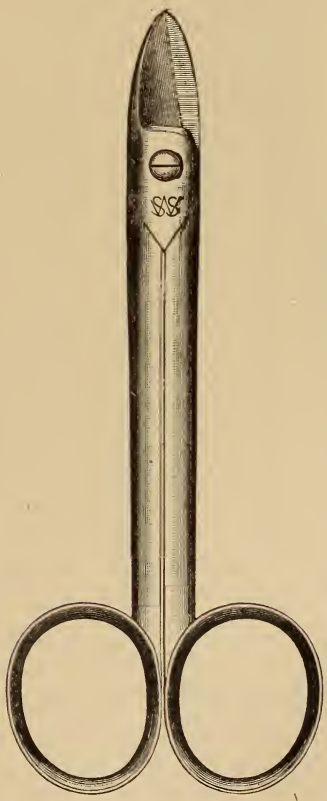


Fig. 784



teeth, only a few tools are necessary, but it is important that they should be of the best selection and some of them of special design.

Fig. 778 shows the writer's soldering pliers. Their delicate proportions

and peculiar form make them especially suited for holding bands while soldering, as well as other pieces of the appliances.

Fig. 779 shows another pair of pliers, for placing pieces of solder in position, picking up small pieces, etc.

Fig. 785

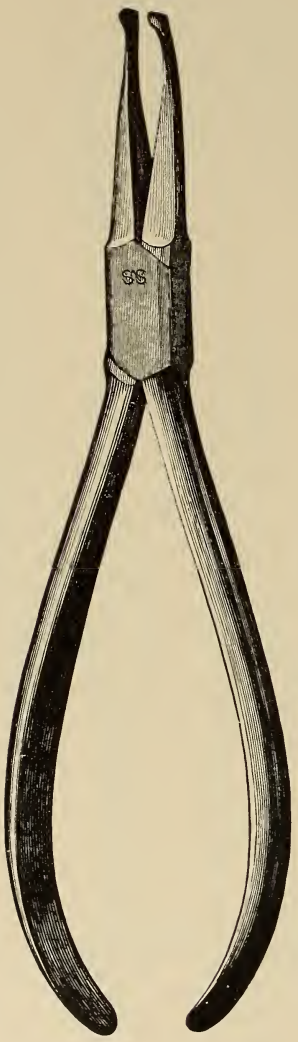
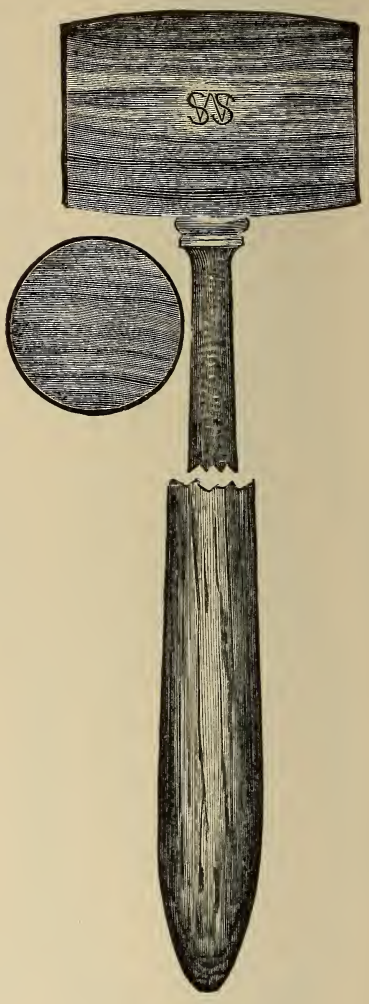


Fig. 786



The writer's band-forming pliers are shown in Fig. 780. These were designed especially and are indispensable for band-making. They also are very useful for most other purposes for which ordinary flat-beaked pliers are used, and are provided with grooves for holding the small square nuts and round wire.

A good pair of wire cutters is essential. The style shown in Fig. 781 is the most satisfactory of the many makes that the writer has tried.

The writer's regulating pliers are shown in Fig. 782. With them any necessary degree of force may be applied for the movement of teeth in a novel manner, illustrated in Fig. 783. In no other way, not even excepting the wedge, is force exerted in so compact a manner, and yet the degree of force is under the most perfect control. While the range of application of this method of applying force is not great, yet on account of its simplicity it is extremely valuable in widening the anterior part of the arches of very young children, as shown in the illustration.

A section of wire which has been softened and pointed at each end is made to rest in pits in the enamel of the deciduous canines. The movement of the teeth is effected by lengthening this wire by an occasional pinch from the regulating pliers. These pliers should never be used on hard wire.

This instrument is also valuable in many other ways, especially in modifying the form of retaining devices without the necessity of their removal.

The flattened portion of the very powerful beaks make it ideal for giving temper to softened wire through slightly flattening the wire.

The writer also uses it with much satisfaction as a hand vise.

Decidedly the most convenient form of scissors for trimming bands, clipping ligatures, etc., is shown in Fig. 784.

The How pliers, for twisting ligatures and for general uses, is shown in Fig. 785.

An ordinary hand mallet and band driver (shown in Figs. 786 and 787) are also requisite. The flat end of the band driver, as here shown, has too long a bevel. It should be shorter and more nearly at right angles, so as not to cut the bands, and occasionally roughened with a fine file to prevent slipping. The round end is for restoring the form to the ends of the tubes of the anchor bands when accidentally bent.

The two wrenches shown in Figs. 788 and 789 are of universal application to all the various nuts of the appliances; one, a single-end wrench, and the other a double-end, or right-and-left, wrench especially designed for the adjustment of nuts of the clamp-bands on lower molars, they being practically inaccessible to the use of a straight wrench. Both are made of steel, nickel-plated, and finely finished.

And very important is a suitable blowpipe for soldering. The writer prefers the one shown in Fig. 790, the invention of a former student of his, Dr. Jos. Grünberg. It has a very delicate flame, and may be quickly adjusted to any desired angle or height.

Dr. Oppenheim, also, has added another useful tool to those already enumerated, for use in connection with the writer's appliances. It is illustrated in Fig. 791, and is for the purpose of grasping a screw or piece of wire and firmly holding it at any desired angle while it is

Fig. 787



Fig. 788



Fig. 789

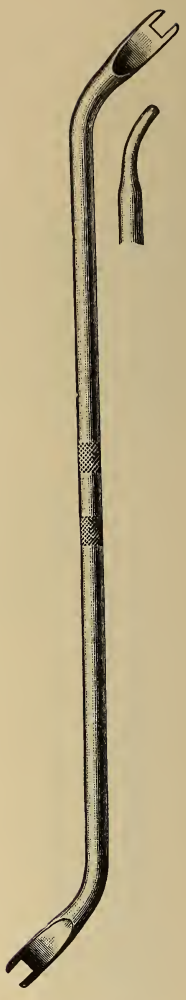
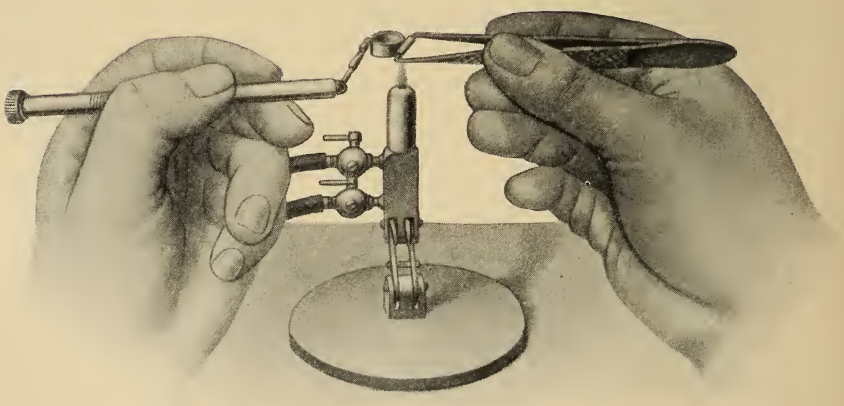


Fig. 790



being soldered or filed. Fig. 792 shows a finely tempered steel instrument, devised by Dr. Grünberg, that has been turned to exactly fit the bore of the friction sleeve of the tubes of the X or D bands—very useful in effecting the proper alignment of these tubes when fitting the bands to the teeth.

Fig. 791

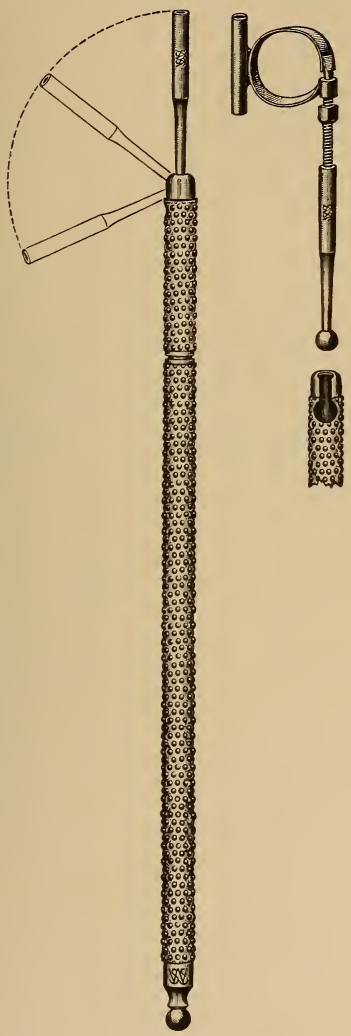


Fig. 792



SOLDERING

It is safe to say that no one will ever attain proficiency in orthodontia unless he acquires much skill in soldering, for the soldering of bands

and the union of tubes and spurs to bands is of such frequent necessity that skill in the work is highly essential. Efforts have been made by some to construct regulating and retaining appliances so that all unions of parts shall be effected by mechanical attachments, as screw-, hook-, or clamp-joints. But to the thoughtful observer it would require no argument to prove that such attachments, beyond certain narrow limits, are impracticable, and that a brazed joint is far stronger, far more compact, cleanly, and inexpensive.

As many of the parts of these appliances are very delicate, it is important that a fine, sharp, steady flame be used in effecting their union by solder. A large or uneven flame would injure and might ruin them. The blow-pipe should be operated with the ordinary foot bellows, or automatic compressor, leaving the hands of the operator free.

Fig. 793

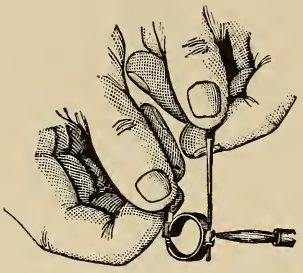
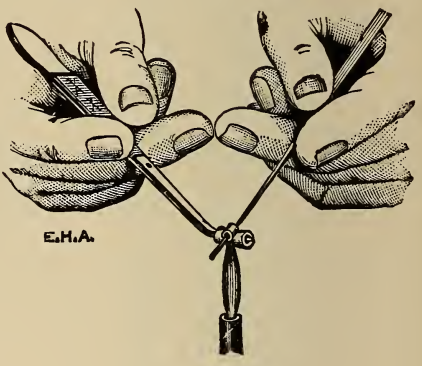


Fig. 794



The plan of soldering introduced by the writer in 1887, of holding the pieces in contact with each other, in the flame at the desired point with the fingers or pliers, avoids completely the time and trouble necessary for investing the pieces, or wiring them together, as formerly. The metal of which these appliances are made is most favorable for soldering in this way, it being so poor a conductor of heat that most of the attachments can be held in the fingers without any perceptible communication of heat to them, provided the flame is suitable.

When union of a small tube with a band is desirable, as in Fig. 793, the tube is best held in contact with the band and flame by means of some delicate instrument that will absorb but little heat. One of Gates' nerve drills with the point broken off is nearly ideal for this purpose. When two small tubes are to be united, as in Fig. 794, pliers may be used for supporting one of them.

This method of soldering is not difficult, most students learning it readily. The only point that may seem at all difficult to the beginner is the holding of the pieces in fixed position just at the time the solder is congealing. This is accomplished by touching one or more of the

fingers of one hand with those of the opposite hand, as in Figs. 793 and 794, to steady them, at the same time holding the pieces gently, not rigidly, just as a good penman holds a pen. After a little practice any of the various soldered attachments may be easily and quickly made.

When the end of a small tube is to be united to a band, it is best to fuse the solder upon the band, then hold the small tube by means of the straight pliers in contact with the solder and again apply heat, as otherwise the solder will usually be drawn into the tube.

The solder best adapted for uniting the different parts of these appliances is silver solder,[1] although any of the various carats of gold solder may be used with cream of borax for a flux. Never use more solder than is necessary, especially in all small attachments—just enough to make the union.

Always avoid overheating. Apply just sufficient heat at the right point from a fine, sharp flame to thoroughly fuse the solder. In every instance avoid heating the screws or nuts. This is to be especially observed with the jack- and traction-screws and the arches *E* and *B*, as great care is used in their manufacture to preserve their elasticity and strength, and this fine temper would be ruined by heating.

Almost innumerable clamps and springs have been devised for holding the pieces while soldering, many of them complicated and bulky. They are entirely useless to him who will devote a little time to mastering the plan of soldering above outlined.

Making Plain Bands.—As the plain bands form such an important part in this system, it is important that proper methods be employed in their making.

We have already stated our reasons for preferring nickel silver for the making of regulating appliances, and especially for the making of bands; yet this metal varies greatly in quality, not only on account of differences in the formulæ from which it is made, but also on account of the manner of manipulation in manufacture.

It is important that it shall be of the proper fineness, thickness, and temper, or it will be harsh and unyielding and difficult or impossible of proper adaptation to the form of the tooth, in which case it will loosen more readily under the strain of tooth movement, will occupy unnecessary space between the teeth, and present a less pleasing appearance.

There is a chance for the development of real skill in the making and fitting of plain bands, and no one can do it successfully without devoting time and study to the technique of the operation.

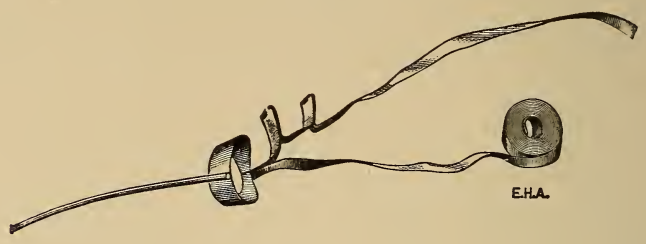
Let it be remembered that each coil of band material must first be annealed in bulk, by heating it to a dull redness, before breaking the

[1] The writer recommends a silver solder for the use of orthodontists by the S. S. White Dental Manufacturing Co. Dr. Grünberg has recently advised that for convenience the solder be drawn into the form of wire—about 18 gauge.

wire encircling it. Then, to simply pinch a short piece of band material about the tooth is to make a loose, crude fitting band, Fig. 796. Pieces of generous length should be used and the band made over the natural tooth, not over a plaster tooth.

Another point of great importance is that the band, in order to fit perfectly, must be stretched about the tooth in the making. This can only be accomplished by slipping the loop of band material around the tooth to the desired point, pulling firmly on the ends of the band material in one direction with the thumb and fingers of one hand, while

Fig. 795



the band-forming pliers are pushed with equal force in the opposite direction at the same time they are closed in the act of pinching the ribbon of metal about the tooth with the other hand.

By this method sufficient pressure is brought to bear to make it fit with the greatest accuracy the surface of the tooth around which it is drawn, and if after soldering the surplus ends be cut off so they will still be united, as in Fig. 795, there will be very little waste to the strips of band material, and ample length for a firm grasp will always be insured. By exercising the proper care a considerable number of bands can be made from each of the coils of band material C, F, and H.

Fig. 796

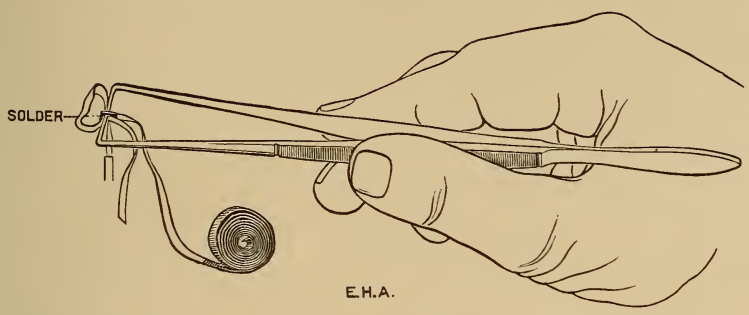


No one should expect other than a very crude band if rough or loose-fitting pliers be used for pinching, for the junction of the pinched portion will then be rounded, as in Fig. 796, instead of sharp and at right angles, as in Fig. 795.

In soldering a band a portion of silver solder about one-eighth of an inch square, wet with borax cream, is placed between the angles of the band and held, by means of the band-soldering pliers, over the flame, Fig. 797. With these pliers uniform pressure is exerted at the exact

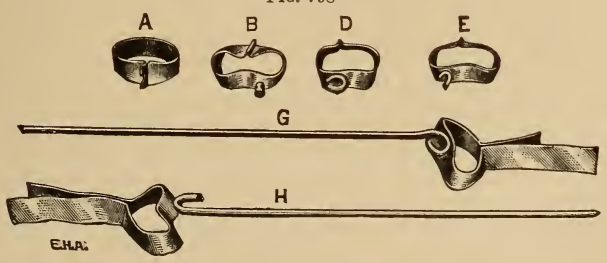
points necessary to insure the seam being even and perfect, while the minimum amount of heat only is absorbed by the pliers; consequently no change of form or injury to them is likely. A further advantage of their use is that their points rest in contact with the band material in such position as to be shielded from the solder, so that none will be fused upon its points, thus avoiding an annoyance of no small moment that is often encountered in the use of ordinary pliers, their contact with the solder being almost a necessity.

FIG. 797



To insure the flowing of the solder in the seam only, plenty of borax should be placed there, but none on the inner surface of the band, as otherwise the solder will be drawn from the seam and there will be faulty union or a thickening of the band, either of which would render it entirely useless. When soldered the band should present a continuous, even inner surface. Any other union is imperfect and is ample cause for condemning the band. The band being properly fitted, it is ready for any attachments which may be required.

FIG. 798



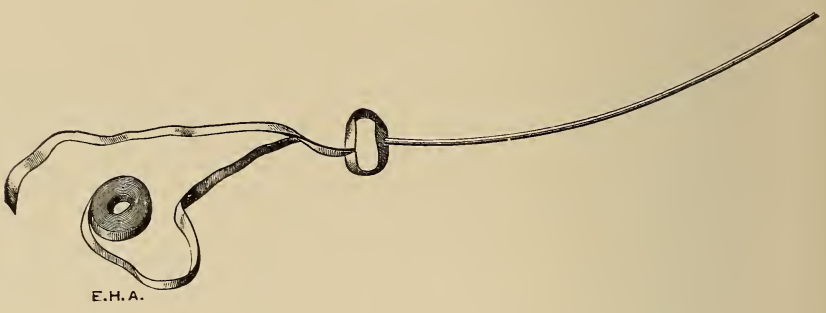
Let us again insist upon the importance of a very hot, fine, sharp-pointed flame in the making of all these attachments, as neatness in such delicate soldering is impossible with a coarse flame.

The principal soldered attachments to the plain bands are tubes R, spurs, and staples. The two latter are made from the wire *G*, as shown in *D*, *E*, *G*, and *H*, Fig. 798, and *B*, Fig. 807.

The attachment of a spur is best accomplished by heating the smoothed end of the wire G, touching it to a large piece of borax, and holding it in contact with a small piece of solder in the flame until it is partially fused, then bringing it in contact with the band at the desired point and again holding it in the flame. After it is fused (Fig. 799) it is clipped off to the desired length, which should never be but slightly greater than the diameter of the ligature which is to engage it, and the roughened ends made smooth with a file. But little solder should be used, as a large amount would form an incline, which would not so well hold the ligature.

If a staple is to be made, the end of the wire is bent into the form of the letter U, the solder is flowed upon the surface of the band first, then the convex portion of the staple is held in contact and the solder re-fused, after which the ends are clipped to about one-sixteenth of an inch in length and smoothed with a file, as in *E* and *H*, Fig. 798. The jaws of the staple should closely fit the piece they are to engage.

Fig. 799



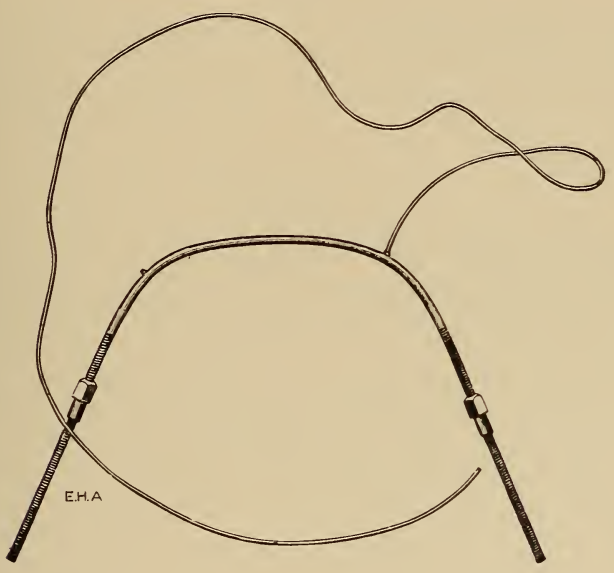
When an oval loop, as in *D* and *G*, Fig. 798, is to be attached, the solder should be flowed first upon the band, and only in sufficient quantity to secure the loop at the given point. A larger amount is unnecessary, and might be drawn into the cavity of the loop.

It is desirable that all attachments, both for moving the tooth and in anticipation of retention, shall, if possible, be made before first setting the band, in order that the pain and trouble of removal and substitution of a new band, after the teeth have become tender, may be avoided.

The untrimmed ends of the band serve the useful purpose of a handle for holding it in the flame and in contact with the piece to be attached, as in *G* and *H*, Fig. 798, and Fig. 799. After the attachments have been made the ends of the bands are trimmed off, leaving them long or short, as desired. If a niche is to be formed to engage some other appliance, the ends are left about one-sixteenth of an inch long, as in *A*, Fig. 798; but if they are not to serve as a means of attachment they may be trimmed still shorter, although it is never desirable to trim them even with the surface of the band. The sharp corners should be rounded.

The canine is the most difficult of any of the teeth to band, but by forming the seam on the lingual incline instead of on the labial, and firmly burnishing the outer surface while it is being pinched, an accurate fit can in most instances be made. Another plan is to pinch a fold in the loop of band material on the lingual incline, while the ends of the band material of generous length are being firmly drawn with the fingers on the labial side. The band is then removed and a little solder flowed into the fold. It is then replaced on the tooth, and the seam made upon the labial surface in the usual way, as described on page 760. While it is slightly more difficult to make a band by forming the seam on the lingual surface of the tooth, yet its appearance is much neater than when the seam is made on the labial surface. It is decidedly easier to

FIG. 800



make and fit bands made of nickel silver than those made of the more unyielding alloys of gold, iridium, and platinum. Yet, as it is sometimes necessary to make them of the latter, it is highly important that the proper skill be developed for their proper making and fitting.

Soft-soldering.—It is frequently necessary to attach sheath-hooks to the arches *E*, which are manufactured in such a way as to give them the greatest possible amount of spring. If the sheath-hooks are attached by means of the ordinary soft solder with which they come provided, the temper of the arches will not be injured, provided only a small, passive flame be used, with just sufficient heat to melt the low-fusing solder.

It is sometimes desirable to attach spurs to the plain arches *E* or the arches *B*, to prevent the slipping of the wire ligatures, although since the

introduction of the ribbed arch this necessity is largely obviated. When spurs are used they should be attached by means of soft solder, in order not to injure the spring of the arches.

The best plan for making these spurs is to fuse a very small piece of this solder upon the end of a section of ligature wire (first having dipped the end of the wire in soldering fluid), then holding it in contact with the arch in the flame. This gives a fine conical spur with brass centre, which is very strong, yet inconspicuous. Fig. 800 shows the arch with spurs both before and after the surplus wire has been cut off. The spur need be no higher than the diameter of the ligature it is intended to support. If higher it will abrade the lips or interfere with their movements.

Jeweller's soldering fluid is used as a flux in making these attachments.

For a more full and minute description of the technique of solde ing and fitting of appliances to the teeth than is here practicable we strongly recommend a most excellent treatise on the subject in pamphlet form, by Dr. Jos. Grünberg, procurable from the S. S. White Dental Manufacturing Co.

ANCHORAGE

Principles of Anchorage.—The correction of the position of a malposed tooth depends upon two important things: first, that the force exerted shall be from the right direction and sufficient to effect the movement; and second, that the anchorage shall be sufficient to resist this force.

In the application of force for the movement of teeth, the crowns are the only portions available for effecting the necessary attachments. Force is usually exerted at right angles, or nearly so, to the long axes of their roots, and their changes of positions may be said to be partial or complete.

In the first instance the change is principally in the crown end of the tooth, it being tipped into position, thereby changing its angle of inclination, with little or possibly no apical displacement.

In the second case the tooth is moved bodily, its coronal and apical displacement being more or less equal, and in the same direction.

Whether the movement shall be partial or complete depends upon the manner of attachment, which determines the distribution of the applied force. In the first instance the attachment must be in the nature of a hinge or pivot, so as to admit of tipping, as would follow the use of a ligature made to exert force practically at right angles to the long axis of the tooth.

To effect the second form of movement necessitates that the attachment of the appliance to the crown shall be rigid, so that tipping will be impossible, the force being then distributed equally to the root.

Details of Anchorage.—As has before been stated, there are but seven distinct malpositions that teeth can occupy. In accordance with the laws of physics, their movement into harmony with the line of occlusion can only be accomplished by the application of force from a fixed base of anchorage in one of three ways—pulling, pushing, or twisting. As "for every action there is an equal and opposite reaction," it must follow that the same amount of force will be exerted upon the anchorage as upon the tooth to be moved, and if the anchorage offer no greater resistance than the tooth to be moved, their equal displacement must follow.

For the moving of teeth we have two principal sources of anchorage—first, and chiefly, that which may be derived from the teeth themselves; second, that gained from suitable attachments to the top and back of the head.

The resistance offered by different teeth varies greatly according to their positions, size, length, and number of roots, the direction from which force is exerted, and also, as we have said, in the manner of mechanical attachment.

Of the many modern improvements in the methods of the correction of malocclusion, perhaps none have been greater than in the devices for securing anchorage. The former bulky and insecure devices for this purpose in the form of vulcanite or metal cribs have become practically obsolete since the perfection of the plain and clamp bands, which make possible much greater control of the anchorage, as well as firmness and stability.

The force should be as direct and positive as may be possible to secure with the conditions at our disposal. The ideal anchorage would, of course, be that from an immovable base. This, however, is probably never fully possible in the mouth, owing to the slight spring of the alveolar process and cushion-like function of the peridental membrane. Some displacement of anchor teeth is admissible, and even sometimes desirable, provided they be kept within the limits of final restoration by means of the inclined planes of the occluding teeth; but if greater displacement than this take place, malocclusion of the anchor teeth, most difficult or even impossible to overcome, may be established. Hence they should be closely watched and careful measurements and comparisons with the original models be frequently made. Any unfavorable movement perceived should be promptly combated. The embarrassment following any considerable displacement of the anchor teeth is so serious that ample anchorage should always be secured in the beginning.

The available anchorage may be said to be of five kinds. They are more or less intimately associated, and are used in combinations or separately, according to the exigencies of requirement. We will designate them as simple, stationary, reciprocal, occipital, and intermaxillary.

Simple anchorage is that form in which the resistance of the moving teeth is overcome by means of an anchor tooth or teeth of larger size or more favorable location, the form of attachment being hinged or pivotal, admitting of the tipping of the tooth to be moved, and the possible tipping of the anchor tooth. This form of anchorage, although often primarily unreliable in itself, may be reinforced by enlisting the resistance of other teeth in the same arch, near or remote in location.

Stationary anchorage[1] is that form in which the attachment to the anchor tooth is essentially rigid, so that its tipping is impossible, and if moved at all it must be dragged bodily through the alveolar process in an upright position. Fig. 801 shows an illustration of stationary anchorage to a molar in the retraction of a canine. The long sheath of the screw is soldered to a clamp-band rigidily cemented and clamped upon the molar, while the angle of the screw engages a tube soldered horizontally to a plain band on the canine. The attachment to the

Fig. 801

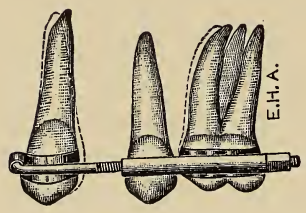
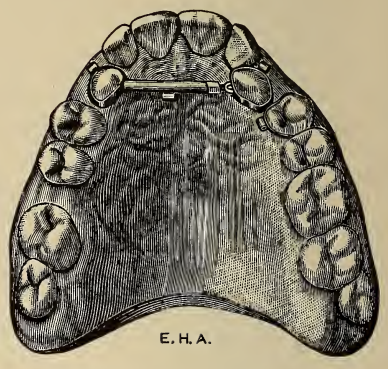


Fig. 802



canine is hinged and designed for tipping. Should any displacement of the molar occur, both root and crown would be moved equally and in the same direction. It will thus be seen that the resistance in this form of anchorage is vastly greater than in the simple form.

Skill and judgment are necessary in the use of this form of anchorage, for its success depends, first, on the absolute rigidity of the attachment and appliance to the anchor tooth, and second, on the amount of force exerted, which must not at any time be so great as to impair the rigidity of the appliance or attachment. This is of vital importance, for any loosening or straining of the attachment would partially or completely change the anchorage from stationary to simple.

Reciprocal anchorage, strictly speaking, is not a distinct form of anchorage, yet its value and possibilities in application are such that it may with propriety be so regarded. It is that form in which one malposed

[1] Angle, Items of Interest, December, 1887.

tooth is pitted against another in the same arch, the tendency of the force, correctly applied, being to move both into the line of occlusion.

Reciprocal anchorage admits of the widest range of application and is the most valuable form of anchorage. Each case should be studied carefully with a view to its use whenever possible, either in its simplest forms, as in Fig. 802, or when a greater number of teeth are to be moved, as in widening the arch (Fig. 811), or in combination with other forms of anchorage. It will be found applicable to a very large percentage of cases, and is an important principle in many of the combinations of appliances to be hereafter shown.

Occipital anchorage is that form in which the resistance is borne by the top and back of the head and transmitted by means of the head-gear and heavy elastics to attachments upon the teeth, as in Fig. 775. This well-known form of anchorage, heretofore principally applicable in the treatment of cases belonging to Division 1 and its subdivision of Class II and to Class III, has, since the development of intermaxillary anchorage, been largely superseded by it.

FIG. 803

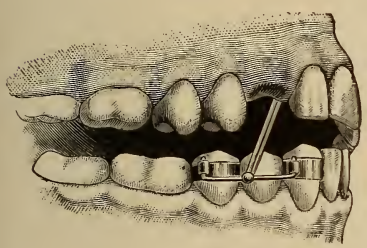
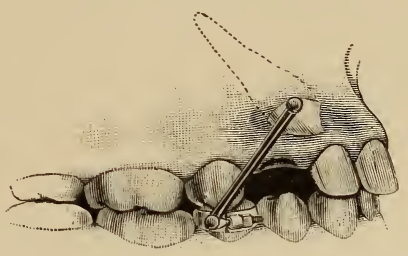


FIG. 804



Intermaxillary anchorage is a new form of anchorage, differing from those already described in that the anchorage or resistance to the moving teeth is derived from the teeth of the opposite arch. It may or may not be used reciprocally.

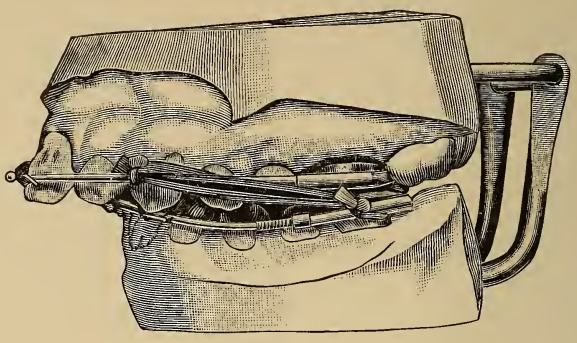
Figs. 803 and 804 illustrate this form of anchorage in cases in which it is not used reciprocally, the elevation of the upper canines being accomplished by means of rubber ligatures attached to devices on the lower teeth, and the lower teeth prevented from elevating by the irresistible pressure of occlusion.[1]

Fig. 893 shows a remarkable case which this anchorage was made to act reciprocally in forcing the elevation of both upper and lower incisors, canines, and premolars. This form of anchorage is direct and powerful, and may often be employed to much advantage. Its importance in the modification now known as the "Baker anchorage" is so great as to mark an epoch in the evolution of orthodontia, for with it

[1] This form of anchorage was introduced by the writer. See Dental Cosmos, 1891, p. 743.

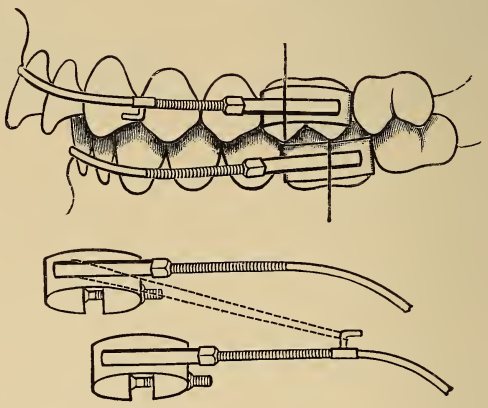
the entire plan of treatment of cases belonging to both Classes II and III has been revolutionized, and instead of the movement of the teeth in these cases being difficult, as formerly, these cases have become, by the correct application of this form of anchorage, among the easiest

Fig. 805



and most satisfactory that we are called upon to treat; that is, if taken at the proper age and intelligently managed. This form of anchorage, as used by Dr. Baker, is shown in Fig. 805, and as improved by the writer is shown in Fig. 806.[1]

Fig. 806



ADJUSTMENT AND OPERATION OF APPLIANCES

Normal occlusion is now recognized as the working basis[2] of orthodontia, and since this recognition has necessitated not only the diagnosis of malocclusion and the art requirements from this basis, but prognosis

[1] See Dental Cosmos, March, 1903.
[2] Angle, Malocclusion of the Teeth, 6th edition.

and treatment as well. This has made utterly useless many of the thousands of appliances appearing in dental literature which were designed for the treatment of individual cases from the basis of "alignment" of individual teeth only, regardless of the demands of the entire denture from the basis of the normal in occlusion. Obviously, then, it would be useless to give here appliances and methods which are now obsolete. Obviously, too, it would be useless to give a number of modern appliances which are in fact but copies of recognized standard forms, differing not in principle, but only in individual matters of detail, and differences, too, that often are extremely trivial and that very frequently show retrogression rather than progress.

It has been the constant aim of the writer to reduce the number of appliances and to avoid adding those that were unnecessary, well knowing that a far greater amount of skill may be developed in the use of a few properly formed appliances or tools than is ever possible with a large number. This is well known among artisans. It is a matter of regret that the literature is again gradually becoming encumbered with instruments which add nothing to the real progress of orthodontia.

The appliances and plans of treatment which will be here given are such as are now recognized as the standard by all the leading orthodontists of this and other countries.

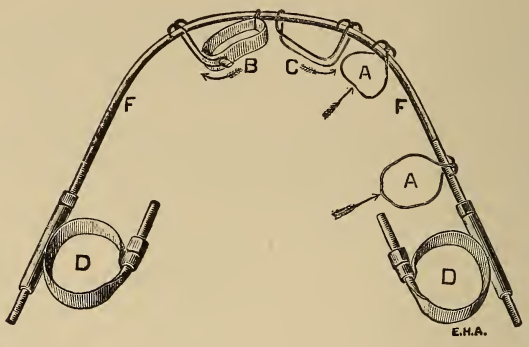
Like all pieces of mechanism, regulating appliances should be judged from the basis of efficiency and simplicity, and an ideal appliance is one that, properly operated, would perform all necessary movements, whether lingual, labial, mesial, distal, of depression, elevation, or rotation, or their combinations, not only with individual teeth, nor of the teeth of one arch alone, but all movements required of all teeth in both arches, carrying all on simultaneously—one applicable to any case of any class, from the simplest to the most complicated in which treatment is practicable, and one that should be under the perfect control of the operator, who might hasten the movement of some teeth and retard that of others, as occasion might require, yet a device so simple as to be easily comprehended, and occasion the minimum amount of inconvenience to the patient. The writer believes we at last have practically all of the requirements we have enumerated in the appliance known as the expansion arch, and shown, with its auxiliaries, in Figs. 769, 807, and 808.

This appliance is made up of one of the arches *E*, plain or ribbed, or the arch *B*, anchored to the teeth by means of the anchor clamp-bands D or X, and used with the auxiliaries of plain or spurred bands, wire ligatures, rubber wedges, and rubber ligatures, according to the requirements of the case. This appliance, in slightly varying combinations, is practically the only one now used by the writer. Its great value and almost limitless range of possibilities will become more and more appreciated in proportion as it is studied and used.

For certain very simple movements of teeth, under suitable conditions, other forms of appliances which are made to act locally will be given later.

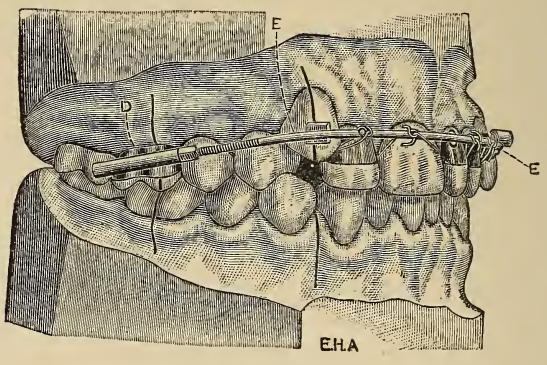
Adjustment of Clamp-bands.—In adjusting this appliance the first step is the fitting of the anchor clamp-bands, either D or X. The use

Fig. 807



of the D bands on the first molars is usually preferable, as these are the largest and firmest of the teeth, thereby affording the firmest anchorage. Occasions may arise, however, in which it may be desirable to adjust these bands to the second or third molars. The X bands on the premolars, used on either one or both sides, may also sometimes be desirable, but their use is only occasionally demanded.

Fig. 808



In adjusting a clamp-band, the nut should first be loosened sufficiently to allow *ample* size for the crown over which the band is to slip. The band should then be shaped between the flat beaks of the band-forming pliers until it conforms approximately to the shape of the crown of the tooth, the shaft of the screw, which should always point forward unless for some special reason, being bent also if necessary. The band

should then be worked carefully over the crown with the fingers and made to slide between gum and enamel to the desired point, and then alternately clamped and burnished until made to conform accurately to the shape of the crown.

One of the greatest blunders made in adjusting these bands is to trim or file the band on its edge in order to prevent supposed interference with the gums. Such procedure only ruins the band. Besides, it is essential that this portion of the band shall pass beyond the swell of the crown and be clamped and burnished to the neck of the tooth to prevent the band from slipping off. This is the most valuable part of the band.

Another blunder frequently made is to begin the clamping or burnishing before the band is well over the crown. In this case part of the band must bear the entire strain, and will be stretched or torn, or the band will loosen and come off.

The screw must not be allowed to project lingually to abrade or interfere with the movements of the tongue. The band should be turned before clamping until the screw is in contact with the adjoining teeth, and after clamping it must still be made to lie in the same position, even though it be necessary to bend the screw, as is often required.

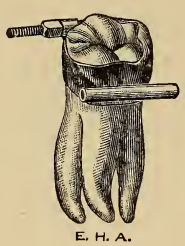
The bands are made to endure the greatest possible strain consistent with their nearly ideal proportions. They will, therefore, bear considerable tightening of the nut, yet if this be carried too far they will be broken. It is usually best not to clamp the band too tightly at first, but to wait until the second or third sitting for the final clamping and burnishing. Clamping of good bands is ample to give all needed firmness without cementing, except in effecting stationary anchorage, as in the use of the traction screw, shown in Fig. 801. Some orthodontists, to guard against the possible disintegration of the enamel underneath the band, always cement it in position. Now, it is a fact which the writer has verified in the use of many thousands of clamp-bands, that the danger of injury to the enamel from them without cementing is practically *nil*, especially when they are constructed from nickel silver. Formerly he always cemented them, but found that in practice it was unnecessary except in cases where there was a noticeable tendency to caries in the teeth of the patient. When the band is to be worn but two or three months in healthy mouths, it seems to the writer that cementing the clamp-bands is a useless procedure. Yet when any doubt exists, it is such a simple operation that it is best to follow the conservative plan and cement them. In cases where the band is to be worn a long time, as in retention, there is then no question as to whether or not it should be cemented. Of course, plain, brazed bands should, of necessity, be cemented in all cases.

Fig. 809 shows a D band which has been properly adjusted to the crown of a molar. It will be noted that it accurately conforms to the

swell of the crown. A small portion of the upper edge has been burnished over the distal marginal ridge. This is important to prevent the possibility of the band working too far over the crown. A band so adjusted offers the firmest anchorage, and cannot be loosened without breaking, or unturning the nut.

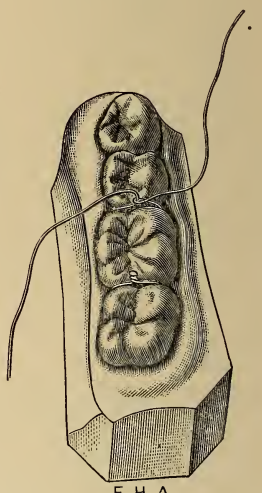
If the teeth to be banded are crowded, care and patience are necessary to work the band into position. This is usually easy with young patients, as their teeth admit of considerable movement. The band is worked between the teeth on one side first, and allowed to remain for a few minutes, then the other side is gently rocked and pressed with the finger, or, better, with a flat piece of wood, until started to place between the teeth. It is then well to allow it to rest for a few minutes, after which sufficient separation will usually have taken place to readily permit of its further adjustment.

Fig. 809



E. H. A.

Fig. 810



E. H. A.

Where space for the band cannot be thus readily made, a very simple and efficient way of providing it is by means of the writer's method shown in Fig. 810, viz., engaging the approximating surfaces of the adjoining teeth with a wire ligature which is tightly drawn and firmly twisted and the ends cut off. After twenty-four hours ample space will have been gained.

It is important that the sheath of the clamp band shall be made to line accurately with the expansion arch. Usually, with proper care in fitting the band, this is easily accomplished. In other cases slight bending of the sheath to alignment, with the instrument made for the purpose, shown in Fig. 792, is permissible. But if there be any considerable variation, as may often be the case, owing to the inclination of the crown of the tooth to be banded, the band should be removed and the sheath

resoldered at the proper angle. This is one of the most simple operations and the work of but a moment, carrying the band to the flame by holding the screw between the jaws of the wire cutters, or with the instrument shown in Fig. 791, and the ends of the sheath by the angles of the band-soldering pliers, all as shown in Fig. 790. In like manner the tube may be shifted mesially or distally—an occasional advantage. The borax flux must, of course, be applied when soldering.

Recently it has been suggested that the sheaths of the clamp-bands should be self-adjusting by having a pivotal attachment to the bands. The utter absurdity of this is obvious, for the band is thus weakened and the firmness of anchorage greatly impaired, besides rendering the appliance more bulky and less cleanly.

Sometimes after adjustment of the anchor-band it is found that the mesially adjoining tooth inclines buccally to such a degree as to prevent the passing of the end of the arch into the sheath. This is readily remedied by unsoldering the sheath from the band and resoldering it, with a piece of metal of sufficient thickness intervening. Usually a portion of a ten-cent piece is ample. By this means the sheath is projected buccally sufficient for the ready insertion of the end of the arch.

What has been said regarding the adjustment of the D bands will, of course, apply to the adjustment of the X and plain adjustable bands also.

For directions for cementing clamp-bands see page 783.

Adjustment of Plain Bands.—Before adjusting, the plain bands must be throughly deoxidized by boiling in dilute sulfuric acid. The tooth to be banded is then cleansed, dried, and protected from moisture. The band is filled with oxyphosphate of zinc of creamy consistence, then carried on the end of the finger to the tooth, upon which cement and band are pressed. With the fingers alone the band is carefully worked nearly to the desired position, and then driven down by a few gentle taps from the mallet and band-driver. The burnisher is now quickly applied to the edges of the band only, and the surplus cement wiped off. When the cement has thoroughly hardened the band should be polished and burnished, as it is well known that discoloration is far less liable with a smooth, polished surface than with a rough one.

A band made as described in the section on Soldering, and set as above, will fit with the most glove-like accuracy, will present a very neat appearance, and will not loosen under necessary strain. If it is defective in any particular, as too large, weakened by crimping, or slightly torn when driven into position, it should be immediately condemned and a perfect one substituted, for sooner or later it will surely fail and cause annoyance.

In banding a tooth where there is much crowding it may be necessary to provide space in advance. Usually, however, by exercising a little care and patience the banding may be done at one sitting.

Adjustment of Expansion Arches.—In adjusting any of the expansion arches, they are first bent to the general form of the dental arch with the teeth in their malarrangement. But as the movement of the teeth progresses it is occasionally necessary to modify this form, gradually approaching the ideal, which corresponds with the line of occlusion. The expansion arch, therefore, becomes a guide and pattern for the proper alignment of the teeth as well as the means of effecting their movement by reason of its elasticity, in connection with the wire ligatures.

Being given the desired size and form and being properly adjusted to the teeth, its further adjustment as to size is effected by tightening the nuts in front of the anchor tubes. The tendency of beginners is to depend principally on the tightening of the nuts for applying pressure on the moving teeth. This, however, is a mistake, as the principal force should be derived from the ligatures and the elasticity of the arch.

Adjustment of Wire Ligatures.—Unquestionably the greatest modern improvement in connection with the use of the arch is the substitution of ligatures of brass[1] for fibrous ligatures, on account of their greater strength, cleanliness, and freedom from stretching or slipping, making their force direct and positive. With them the possibilities in the use of the arch are greatly extended, shortening the time of treatment, and making easy much that was impracticable or even impossible before. One of their valuable qualities is that they may be retightened by twisting, without renewal, possessing thereby, in addition to their primary usefulness, the ideal power of the screw, and obviating the necessity for the oft relinquishment and reapplication of pressure on the moving tooth, as must follow the use of other ligatures—the principal source of pain and inflammation in tooth movement. It is very important, however, that only wire of the proper metal, quality, and size be used. It is also important that in temper it shall be very soft, so made during its manufacture. Wire of spring temper is entirely useless.

When applying a wire ligature a piece long enough to be firmly grasped by both hands should be used, so that strong steady tension may be exerted when making the twist. This should never be more than three-fourths of a turn at first, as greater twisting gives no additional strength, but adds only useless bulk. The surplus ends are then clipped off, leaving projections one-eighth of an inch long. These ends are then curled under the arch, as correctly shown in Figs. 807 and 811, thus providing a smooth surface for the lips. Never attempt to bend the twisted portion of the ligature out of the way, as by so doing the entire strain is brought on one strand, and the ligature usually broken.

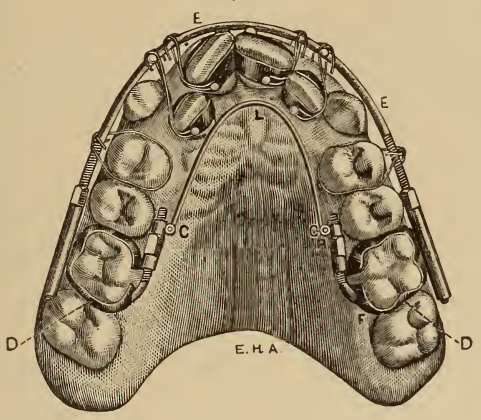
In retightening the ligature, firmly press the tooth and arch between the thumb and finger while giving it another half-turn with suitable pliers. Either the large or medium-sized ligatures should be used for

[1] Angle, Regulation and Retention of the Teeth and Fractures of the Maxillæ, fourth edition.

the movement of teeth, yet the size of the ligature, the degree of force exerted, and the frequency of their renewal or retightening must be left wholly to the judgment of the operator. The usual plan is to tighten the ligature once or twice a week, although once in two weeks is sufficient.

Although the uses of the wire ligature in orthodontia are limitless, there are three principal ways of applying it in ligature form: first, the simple ligature, as in *A*, *A*, Fig. 807, where it is made to engage a single tooth and the expansion arch, where direct labial or buccal movement is required; second, where rotation and possibly labial movement is required the ligature is made to engage the expansion arch and a spur upon a band cemented to the tooth, as in *B*, Fig. 807; third, the double loop ligature, as in *C*, Fig. 807, to effect the same movement. The ligature applied in this manner is more uncertain in its results than when applied as last shown, and should rarely be used.

FIG. 811



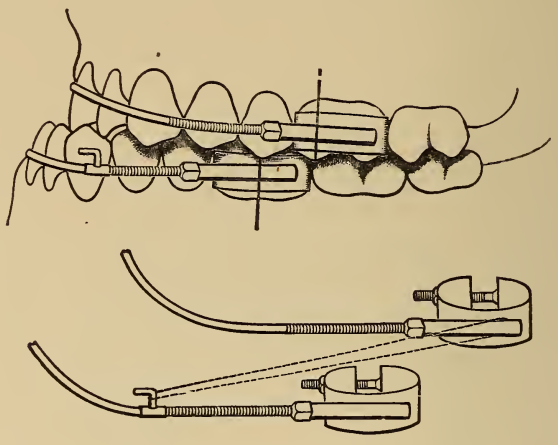
Combination Adjusted.—Fig. 811 shows the expansion arch adjusted to the teeth of the upper dental arch in the very complicated case shown in Fig. 872. This case required the movement of all the teeth in both arches and offered the severest test to a regulating appliance, at the same time offering us the best of opportunities for its study, with a view to its proper adjustment and operation, not only in this case, but for most general uses. Its more extended uses in special cases will be noted later in the treatment of individual cases. In this case the upper dental arch requires much widening, while both centrals and both laterals are to be carried labially and rotated, and the canines are to be elevated in their sockets.

Plain spurred bands and ligatures were adjusted to all the incisors for their combined labial movement and rotation, the spurs on the plain bands having been so placed that force exerted by reason of the

elasticity of the arch through the wire ligatures bore most heavily on the angles of the teeth that were turned lingually, and as they were rotated they were also drawn labially. By using the ribbed expansion arch and notching the rib for the more stable attachment of the ligatures, the direction of force for moving these teeth was absolutely controlled.

The first molars, attached to the expansion arch through the clamp-bands, were moved buccally by reason of the lateral spring of the expansion arch. The first premolars were moved in the same direction through their attachment to the arch by plain wire ligatures, and the second premolars through contact with the screw of the D bands. Pressure on the canines to move them lingually was intensified by rubber wedges stretched between teeth and arch and the superfluous ends cut off, as shown in Fig. 808.

FIG. 812



By carefully studying this picture it will be seen how perfectly force is distributed to accomplish the various necessary tooth movements, and how, as in all fine mechanisms, each part assists and is in harmony with each other part. For example, note how perfectly the force is reciprocated from one moving tooth to another; from one lateral half of the dental arch to the other, and how this is intensified by the pressure on the centre of the expansion arch in front, the tendency being when pressure is exerted at this point, as in all arches, to spring the ends farther apart. As the central incisors were rotated, much force was exerted upon them at their diagonally opposite corners; in reality the arch operating on each as two levers combined, the power ends acting in different directions. No tooth can resist this force. At the same time all four incisors were carried forward by the irresistible force of what is practically two jack-screws combined.

In the anterior teeth, one lateral incisor reciprocated its force with the other, one central with the other, all in perfect harmony. Note, also, what

complete control we have over the teeth singly and collectively, yet at the same time the anchorage is derived from practically all of the teeth in the arch.

In applying force to the moving teeth the medium-sized brass wire ligatures were used, being renewed or retightened once or twice a week, all the force they would bear being applied to them. The nuts of the expansion arches were tightened about one revolution per week, always *after* the ligatures had been tightened. The expansion arch was occasionally removed and slightly modified as to form, and the full amount of lateral spring maintained.

With this appliance we may not only expand the arch in all directions, as required in this case and here shown, but, as we shall see in the section on Treatment, we may widen or narrow either or both of the dental arches on one or both sides, or we may lengthen or shorten one or both of the lateral halves. We may move a single tooth in any direction, or we may lengthen the teeth, and, to a limited extent, effect their shortening.

In adjusting the arch, as here shown, it will be seen that it is placed high up toward the gum, as it should be in all cases. This is necessary in order to keep intense, rigid tension upon the moving teeth, for if the arch be allowed to slip down (its natural tendency) toward the points of the teeth, it will lose much or all of its force, and become a wobbly, inefficient incumbrance. For this reason the spurs upon plain bands for engaging the ligatures should be placed as high up, or as near the gum, as possible, and also, at such an angle as will prevent the ligatures from slipping off.

A common failing of the inexperienced is to give the arch so much lateral spring as to cause buccal displacement of the anchor teeth in cases in which no buccal movement of these teeth is necessary.

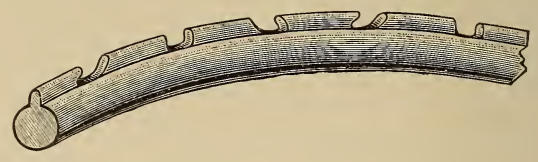
In using the plain expansion arch, as here shown, spurs are soldered at points best calculated to prevent the ligatures from slipping and to control the desired direction of force. These spurs are attached with soft solder, as previously described (page 764). It is impossible to always foretell the exact location at which these spurs should be placed so that they may be attached before the arch is adjusted, making the removal of ligatures and arch and their readjustment after the spurs have been added often necessary. Now, this has a serious objection, for it must be remembered that the relinquishment and reapplication of force to moving teeth is the most certain and speedy method of exciting inflammation, and should be avoided whenever possible. For this reason the brass wire ligatures should be retightened without renewal as long as is practicable.

To avoid the necessity of removing the plain arch for the attachment of spurs, the ribbed arch was invented, and it is of decided advantage, for notches may be made in the rib at desired points quickly and easily

with the arch in position upon the teeth, thus avoiding much pain and the liability of exciting inflammation.

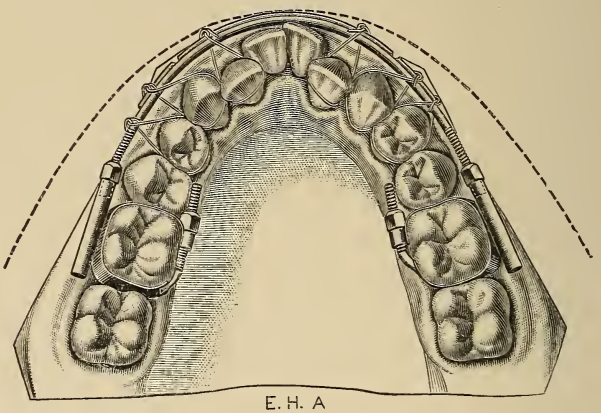
The notches are best made with a delicate knife-edge file, and should be made deep enough and at the proper angle to effectually prevent the ligatures from slipping. Mere V-shaped notches are useless. They should be given decided angles, as shown in the enlarged section, Fig. 813. The ribbed arch, as here shown, Fig. 813, also gives considerable additional force in widening the dental arch, so that reinforcement by means of the lingual wire (Fig. 811) is now rarely necessary.

Fig. 813



Objections have been offered to the ribbed arch on account of its supposed greater liability to abrade the mucous membrane of the lips, but the writer has always found that the arch was not properly adjusted when this occurred, but had been allowed to stand out from the teeth, sometimes to an absurd degree, instead of conforming compactly to the teeth, as shown in Fig. 769. Again, the superfluous ends of the rib should

Fig. 814



be removed with a file and the arch neatly burnished, especially if, through necessity, the arch is given much prominence on account of the position of the canine teeth. When intelligently studied and properly managed the great value of the ribbed arch will become better and better appreciated.

Fig. 814 shows the adjustment of the combination to the lower dental arch. It will be noted that the principal necessary movement of the

canines is buccally, so the notches in the arch have been placed well back to best accomplish this movement. Later it may be necessary to place bands and spurs on the right canine and on the central incisors in order to better control their movement for partial rotation.

By the addition to this combination of sheath-hooks and rubber ligatures used in the Baker anchorage, all of the upper teeth may be moved distally and all the lower teeth mesially, as illustrated in Fig. 706, or these movements may be reversed, as shown in Fig. 812, and all this in connection with any other tooth movements that may be required in either or both arches.

The modifications of form and directions of spring, plus the modifications in ligature attachments, make it possible to derive wonderful control of force in tooth movement, and in the use of this appliance it is possible to cultivate a very high degree of skill. It typifies efficiency and simplicity. It is easily applied, and is so stable in its attachment that there need be no slipping or loss of power. It is cleanly, and occupies a position in the mouth that causes the least inconvenience to the patient. If this device be intelligently managed, it need interfere but little with the normal functions of the mouth. On the contrary, however, if improperly managed it becomes a constant annoyance, as has been said, and one of the most wobbly and useless of devices.

In its proper use the widest range for reciprocal anchorage is possible. We may also gain simple and a considerable degree of stationary anchorage by reason of the tubes and firm attachment of the anchor-bands to the teeth used as anchorage, and also, as we have seen, the very valuable intermaxillary anchorage.

The necessary direction and distribution of force should be carefully studied in each case, as well as the effect upon the anchor teeth and all teeth that are in correct position.

Let us repeat that the arch should always be made to lie approximately close to the teeth, so as to interfere as little as possible with the functions of the lips.

It should be remembered that as its force in tooth movement is exerted usually by its elasticity, its careful bending in order to secure the proper degree and direction of force is of much importance. To make the most of this possibility, and at the same time avoid interference with desired movements or with teeth already in correct position by binding, is the most difficult problem in its management, and yet it is easily solved if intelligently studied in each case.

As a result of years of experimenting, it is believed that, as here shown, with its improvements and attachments (Fig. 760), it is very nearly perfect.

In order that the patient may become gradually accustomed to the appliances, the bands should be worn for two or three days, then the arch added without ligatures for three or four days more, and finally, all care-

fully and thoroughly adjusted and the ligatures applied for the movement of the teeth. They should be very light of tension at first, the object being, of course, to begin so gently that the patient may become accustomed to the wearing of the device with no pain and with but the minimum amount of inconvenience, all of which is easily possible. The tendency of all appliances upon the teeth is at first to excite more or less inflammation, which will be in proportion to the amount of force exerted; therefore we cannot too strongly recommend that the adjustment of the appliances should always be gradual, and the force exerted in the beginning most gentle. Later, much pressure can be borne with little inconvenience.

Although in cases met with for treatment the malocclusion always differs, the adjustment of the expansion arch as here given is practically always the same, the principal difference being in the form given the arch by bending in order to exert force in the desired direction, and in the direction of the ligatures and their attachments to the teeth to be moved.

Combinations for Intermaxillary Anchorage.—Fig. 806 shows a very important combination of the expansion arches in which the intermaxillary anchorage is used in the movement distally of the teeth of the upper and mesially those of the lower arch in the correction of the malocclusion of cases belonging to Class II.

The expansion arches are adjusted in the usual way, sheath-hooks having been attached to the upper at points opposite the lateral incisors. Either the plain or ribbed arches may be used, but the plain arch is preferable in this combination unless other movements of the incisors and canines are necessary, as already described, and illustrated in Fig. 811. The force is exerted by means of one or more small rubber ligatures on each side, which engage the sheath-hooks on the upper expansion arch and the distal ends of the sheaths of the anchor-bands on the lower molars. For description of the operation of this combination of appliances in treatment, see page 851.

The combination of appliances for the treatment of cases belonging to the subdivisions of this class is identical with that just described, except that intermaxillary force is limited to the side of the arches in distal occlusion. Only one sheath-hook should be used, with its accompanying rubber ligatures.

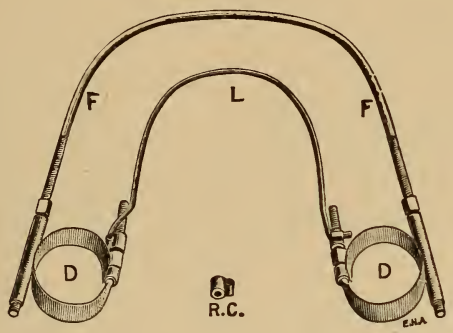
In the treatment of cases belonging to Class III the same combination of appliances is used, but the plan of operation is reversed, as shown in the diagram (Fig. 812). The sheath-hooks are attached to the lower expansion arch, well forward, and rubber ligatures are stretched between them and the distal ends of the sheaths of the anchor-bands on the upper molars.

For the treatment of cases belonging to the subdivision of Class III the same combination of appliances is used, with force from the rubber ligatures exerted on the abnormal side only.

It will be seen that all cases of all classes may be treated with this appliance, and, we now believe, more quickly, more easily, far better, and with far less inconvenience to the patient than with any other form of appliance. It is the one that seems to be most natural to meet the demands of occlusion, for with it we can have control of the entire dental apparatus—something impossible in the use of the innumerable appliances that have been devised for the correction of symptoms only, without regard for the laws of occlusion. He who will study its possibilities will be more and more impressed with its wonderful efficiency and great simplicity.

Expansion Arch Reinforced.—The elasticity of the plain expansion arch is sufficient to exert ample force for widening either of the dental arches; yet in very rare instances where the patient has reached maturity, the force may not be sufficient to accomplish the desired movements as rapidly as may be wished. To meet this limitation the arch may be reinforced by a piece of spring wire, which should be adjusted to exert

FIG. 815



pressure upon the lingual surfaces of the anchor-bands, as in Figs. 811 and 815, and attached on each side by uniting two short tubes, R and D, at right angles, the longer one slipped over the end of the screw of the D band, and the ends of the lever bent sharply at right angles and made to engage the short tubes. Any desired degree of force may be easily gained with this simple method of reinforcement.

A simpler way of securing the reinforcement spring is to insert its finely pointed ends, bent sharply outward at right angles, into very delicate perforations made in the anchor-bands at their mesio-lingual angles, as in Fig. 878, the ends passing through the band and extending between enamel and band.

In Fig. 815 the threaded ends of the arch are seen to project through the distal ends of the sheath. This is never permissible. The ends of the arch should be clipped off even with the ends of the sheaths and the roughened ends made smooth, otherwise painful abrasions of the cheeks are likely to follow.

MISCELLANEOUS COMBINATIONS

Traction-screw.—Although there are many possible combinations with the traction-screw, in reality its uses should be limited to two or possibly three. Formerly its most important use was that of retraction of that most obstinate tooth, the canine, as shown in Figs. 816 and 817. This it accomplishes so easily and so perfectly, when properly adjusted and managed, that it easily takes rank, we believe, over all other appliances for this purpose; but since the advent of intermaxillary anchorage, making extraction in treatment unnecessary, its use is rarely required.

In its correct adjustment the canine and the anchor tooth are carefully banded after the manner described for adjustment of the plain and anchor-bands. The traction-screw is then held in position, and the short and long sheaths made to touch the bands at the exact points they are to occupy when soldered. With a suitable instrument the anchor-

Fig. 816

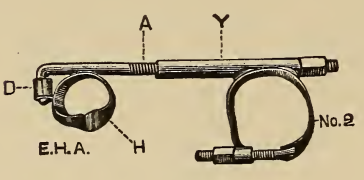
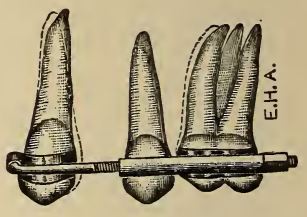


Fig. 817



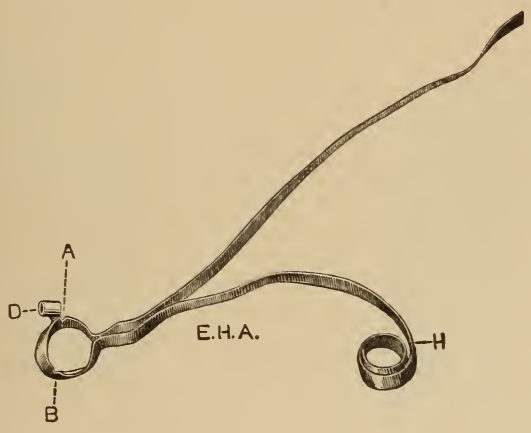
band is scratched parallel with the long sheath to indicate its alignment. The side of the long sheath is then filed to permit of close contact with the band and to give increased surface for the solder, filing through being carefully avoided. The band is then replaced, and the exact point of contact of the edge of the short sheath with the band on the canine is located and indicated by a suitable mark. Lest this be obliterated upon soldering, the band may be perforated at this point with a small drill. Having noted as accurately as possible the angle at which this sheath shall stand to properly line with the right angle of the shaft, minute notches are made in the edge of the band mesially and distally, to line with the end of the sheath (Fig. 818). The bands are now removed from the teeth and the sheaths from the screw, and a minute piece of solder partially fused upon the edge of the short sheath at the point intended for attachment to the band. It is then held with pliers in the left hand, the band being held by its untrimmed ends in the right hand, the end of the sheath lining with the notches *A* and *B*, Fig. 818, and the solder fused by contact with the flame at the proper point.

It is highly essential that the sheath be attached at the right point and at the proper angle, or the angle of the screw will not fit.

Be it remembered that the sheath attached to the canine band must always stand at right angles to the long axis of the tooth, that a free hinge-like movement of the tooth in retraction may be gained; not parallel with the long axis, as some will persist in attaching it, with resultant binding and prevention of free movement.

The surplus ends of the band are now trimmed off and smoothed, and the band deoxidized and cemented in position. While the cement is hardening the long sheath is soldered, according to alignment, to the No. 2 band. It is then cleansed and slipped upon the screw and the nut adjusted, the angle is hooked into the sheath upon the canine band, and the clamp-band slipped over the crown of the molar and gently tightened. It is allowed to remain a day or two before cementing, in

Fig. 818



order that this operation, so important to thoroughly perform, may be accomplished without interference by pressure from the approximal teeth, and also that both the canine and the anchor tooth may slightly move and become more perfectly adjusted to their relations with the two bands.

The proper length of the screw having been determined, it is cut off behind the nut. Heat must in no instance come in contact with any portion of the shaft of the screw.

Before finally cementing the molar band in position it should be removed, and it and the crown of the molar thoroughly cleansed and dried. The crown being properly protected from moisture, cement is mixed to the correct consistence and the interior of the band nearly filled. The angle of the traction-screw is then inserted into the short sheath, and the anchor-band and cement carried down over the crown

of the molar with the thumb and finger, forcing the cement well down by pressure from the thumb. The band is quickly worked to the desired position, and the nut of the band tightened until it is firmly clamped. The superfluous cement is then wiped off, and the patient dismissed until the next sitting before tightening of the nut of the traction-screw is begun, in order that the cement shall become thoroughly set and the most rigid possible attachment gained.

If the operation thus far has been carefully performed, the nearest approach to stationary anchorage possible to obtain in the mouth will have been gained, so that the canine may be moved distally without changing the relation of the occlusal planes of the anchor tooth with those of the opposite jaw. It is very important, however, not to strain the attachment by overtightening the nut of the traction-screw at any time. One-half a revolution the nut each day or just enough to exert a slightly snug feeling upon the canine, is all the force that should be exerted at any one time.

FIG. 819

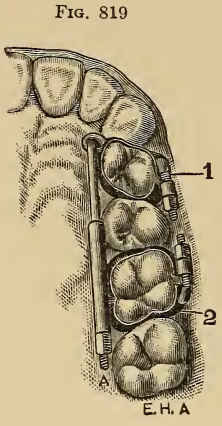
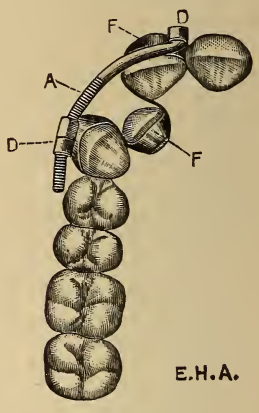


FIG. 820



It is very important that the angle of the screw be passed into the sheath its full length, otherwise it will be broken when force is exerted.

If it is desired to rotate the canine as it is moved distally, it may be accomplished by using a staple instead of a sheath for engaging the angle of the traction-screw, as shown in Fig. 819. In this instance the angle of the screw is parallel with the long axis of the tooth, instead of at right angles to it, as when the tube is used. In this manner force is exerted on one side of the band only, and rotation as well as retraction takes place.

The shifting of the canine lingually or labially in its distal movement may be accomplished by bending the screw where it enters the sheath. As the nut is tightened the screw is gradually straightened as it is drawn into the sheath, thus arranging the teeth in proper alignment.

Fig. 819 shows the use of a traction-screw in effecting rotation of a premolar tooth in combination with the clamp-bands Nos. 1 and 2. The angle of the screw engages a staple made of the G wire soldered to the mesio-lingual angle of the band encircling the premolar. By tightening the nut at *A*, traction force is exerted on one side only, while resistance in the opposite direction is offered by the intervening premolar. The great power thus exerted makes this the most efficient method known of rotating a premolar, and is one that is occasionally used by the writer, always with much satisfaction, but only used when a single tooth is greatly turned upon its axis, as in cases belonging to the first division of Class II, where, after all the other teeth have been moved into their normal relations, it is desirable to remove the expansion arch and effect retention, when rotation of this tooth may be finished, as here described. In such cases the expansion arch may be used at the same time, in combination with this appliance, in which case the clamp-band D would be adjusted to the second molar. Of course, all ordinary rotation of premolars would be effected in the usual way, or by means of plain spurred bands, wire ligatures, etc., in combination with the expansion arch.

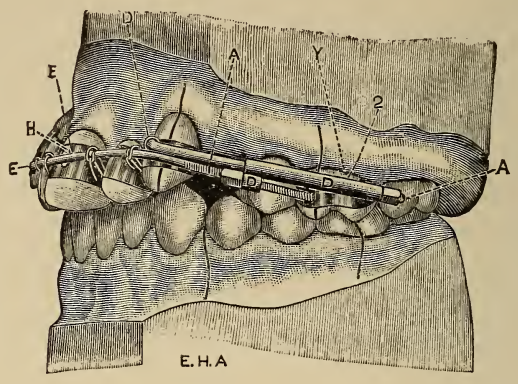
In Fig. 820 is shown another use of the traction-screw in effecting the labial movement of a lateral, and at the same time providing space for its movement. A strip of band material *F* is looped around the lateral, the ends resting on the labial surfaces of the adjoining teeth. To one end is soldered vertically one of the short tubes *D*, while on the other end is a similar tube attached horizontally. Into these tubes the traction-screw is placed, being bent to conform to the proper curve of the arch, and as the nut is tightened the ends of the ribbon of band material are pushed farther apart, thus providing space for the lateral as it is carried into correct position. This combination is now practically obsolete for the movement of the lateral, as here described, or for any of the anterior teeth, the same movements being far more easily accomplished by means of the expansion arch. Yet it is valuable on rare occasions for moving buccally a premolar that is in marked lingual occlusion, as in Fig. 828, as it effectually provides space for the tooth while moving it buccally. When so used the screw is left straight, lying close against the buccal surfaces of the teeth.

Fig. 821 shows a combination of traction-screw and expansion arch for shortening one of the lateral halves of the dental arch, and at the same time correcting malpositions of the incisors.

The traction-screw should be first adjusted, as already described, and in addition it should be provided with one of the tubes *D* soldered to the side of the sheath *Y*, near its mesial end. This is for the reception and support of one end of the expansion arch in place of the usual D or X band. The nut of the expansion arch is to bear against this tube, and when so used the nut should be reversed, the extension flange turned

mesially. The other end of the expansion arch is supported in the usual way, as in Fig. 808. As the canine is retracted into the space made vacant by the loss of the first premolar, the malposed incisors are rotated by means of the ligatures, bands, and spurs, as is well shown in the

Fig. 821



engraving, and also in Fig. 811. This very efficient combination was formerly a great favorite with the writer, but it is now rarely employed, as intermaxillary anchorage has made the establishment of normal occlusion in such cases easily possible and the sacrifice of the premolar unnecessary.

Fig. 822

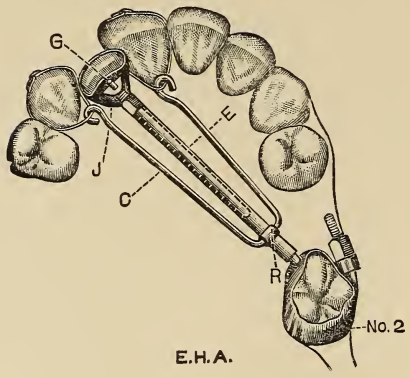
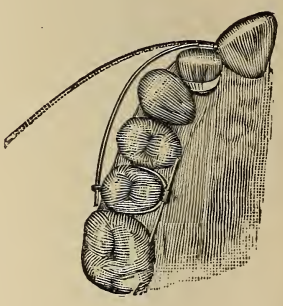


Fig. 823



Jackscrew.—Since the Dwinelle jackscrew was introduced in 1848 for orthodontic purposes, it has been much employed by dentists. The writer's jackscrew was formerly a very important part in many of the combinations of his appliances, and notwithstanding that he believes he is the author of by far the most perfect form of jackscrew yet given to the profession, and one that is widely used and often imitated, he believes that in the requirements of modern orthodontia it is one of the

poorest of appliances and that its use should be practically discontinued, it having been superseded by the expansion arch, for practically all of the movements possible to accomplish with the jackscrew are better and more easily performed with the expansion arch. With the latter we may have complete control of the force exerted on both anchor and moving teeth, individually and collectively, at the same time guarding the positions of those teeth already in the line of occlusion, while with the jackscrew our control over the force is necessarily greatly limited. Yet in favorable cases, which are rare, it will doubtless always be a desirable method of exerting force, owing to its great simplicity and power. Fig. 822 shows one of the writer's favorite methods of using the jackscrew.

An anchor band provided with a spur of wire, *G*, engages one end of the jackscrew. The flattened end is notched and engages a staple soldered to the lingual surface of a band on the tooth to be moved. The jackscrew is powerfully reinforced by a section of the wire *G*, as illustrated. This wire engages one of the tubes, *R*, soldered at right angles to the sheath near its base, its ends being bent in the form of hooks which engage wire ligatures encircling the canine and central incisor.

Lever.—The spring lever, L, also formerly played an important part in the combinations of the writer's appliances for accomplishing rotation of the teeth, but with it, as with the jackscrew, it is difficult to control the distribution of force, so it, also, has been largely superseded by the expansion arch.

In some instances, however, it is valuable; for example, after teeth have been rotated and have, through accident, partially relapsed, they may be easily readjusted, as it requires but little force, by means of a band provided with a tube, R, for the insertion of the power end of the lever, the long end being sprung around and attached to a favorably located anchor tooth which may be reinforced, as shown in Fig. 823. Or the attachment to the anchor teeth may be effected by wire ligatures.

Double rotation, as shown in Figs. 824, 825, and 826, may also be accomplished by means of the lever made to exert force by engaging tubes, or spurs and ligatures, as shown in the engravings; but we insist that they should rarely be employed in the first adjustment of the teeth, as teeth in these positions are usually only the prominent symptoms of more or less general malocclusion which demands attention first. For this reason the expansion arch, acting upon all of the teeth, thus providing space for the moving teeth, as well as effecting their movement, is best. But, as we have said, for teeth that have partially relapsed these are simple and efficient ways of readjusting them, as well as for their temporary retention.

A novel way of effecting double rotation and retention in simple

cases is shown in Fig. 827. Spurs or tubes soldered to the mesio-labial angles of bands on the central incisors are engaged by a wire ligature, which, being tightened, draws the teeth mesially, while force in the opposite direction is exerted by a rubber wedge stretched between these teeth and resting in contact with their mesio-lingual angles.

Fig. 824

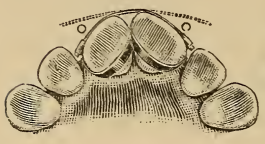


Fig. 825

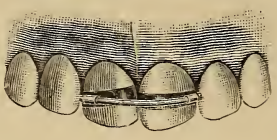
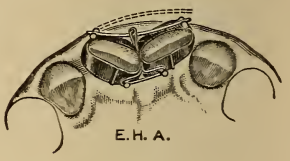


Fig. 826



Another simple but often useful little appliance is shown in Fig. 828, where a tooth is being moved into the line of occlusion by means of either a rubber or wire ligature made to engage the tooth to be moved and a section of wire G, which is held in position by attachment, either by solder or a tube, to a clamp band encircling an adjoining tooth.

Fig. 827

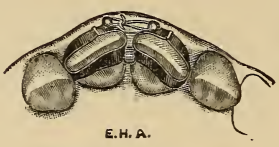


Fig. 828

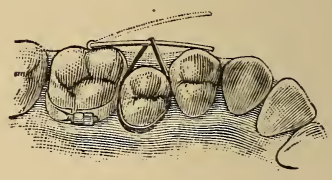
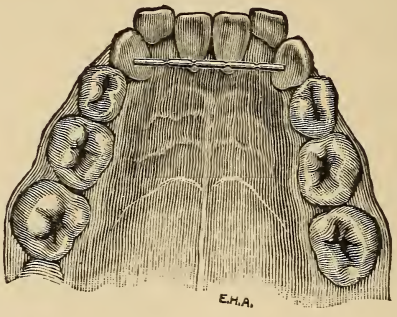


Fig. 829 shows the simplest of all regulating devices, yet one that is very efficient and valuable, especially in increasing the distance between deciduous canines, as here shown, to release lateral pressure upon erupting permanent incisors.

Fig. 829



It consists of a section of wire G, the ends sharpened and made to rest in delicate pits in the enamel of lower deciduous canines. Irresistible force is brought to bear on these teeth by an occasional pinch of this

wire with the regulating pliers, the effect being to lengthen the wire. The lower teeth so moved will act through their inclined planes upon the upper canines, and in like manner effect their buccal movement, thereby releasing pressure from the upper permanent incisors. This would be the ideal treatment for such cases as that shown in Fig. 712.

Fig. 830

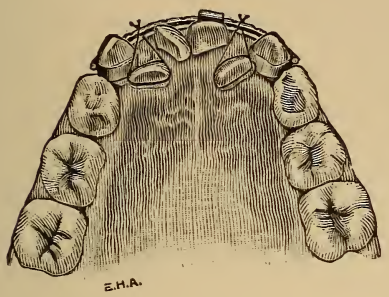
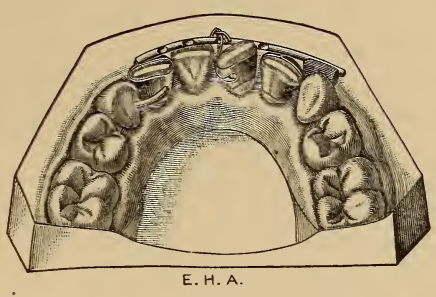


Fig. 831



As here described, it is useful, of course, only on young patients, with the wire pinched only at long intervals, say a month intervening. The same principle, however, is often made use of by the writer in older patients. In these cases a thoroughly annealed section of one of the expansion arches is used, its end secured by solder to bands cemented upon the canine teeth, as shown in Figs. 830 and 831.

RETENTION

After malposed teeth have been moved into the desired positions, it is of the greatest importance that they be mechanically supported until all tendency to return to their former malpositions has subsided; but it cannot be too strongly insisted upon that unless such occlusion has been established as will enable the inclined planes of the cusps to ultimately act in harmony for mutual support, permanency of the teeth in their new positions after the retaining devices have been removed cannot be hoped for. It should be borne in mind that all retaining devices are only temporary assistants to the permanent establishment of the normal functions of the occlusal planes of the teeth, and of harmony in the forces which act upon the teeth.

Time Required for Retention.—The time required for mechanical retention varies, according to the age of the patient, occlusion, tooth movements accomplished, length of cusps, health of tissues, etc., from a few days to a year or two years, or even longer, while perhaps in rare instances retention may be required for an indefinite period.

The support of teeth that have been directed into correct positions during the period of eruption is usually required for a few months only,

while a much longer period (at least a year) would be required for the same teeth if moved after the full development of their alveoli.

Again, owing to the great disturbance of the fibers of the peridental membrane of a tooth which has been rotated, its retention requires a far longer time than if the movements labially or lingually had been accomplished.

A rule of general application may be made, that three times the length of time will be required for retention of teeth of patients aged twenty-one years as for those of patients aged twelve, the same tooth movements having been performed.

There is usually a temptation to remove the appliances before the teeth have become thoroughly established, and many are the failures from this cause of otherwise well-conducted cases. As so much depends upon this part of the operation, it is far better that the appliances be worn even longer than necessary, than that they be too early removed.

Principles of Retention.—As the tendency of teeth that have been moved into occlusion is to return to their former malpositions, the main principle to be considered by the designer of a retaining device is the antagonizing of the teeth in the directions of their tendencies only. Very slight antagonism is required, but its exercise must be constant. If the student will keep this fact in view he will realize that only delicate devices are necessary, and will be impressed with the utter uselessness of much of the bulk and material composing so many of the retaining devices shown in our literature.

With this in view, each corrected case should be carefully studied in connection with the original models, noting the various directions in which the teeth are inclined to move.

To secure retention we have at our disposal support or anchorage from the following sources: first, reciprocal, or the pitting of one tooth against another, their tendencies being to move in opposite or different directions; second, teeth already firm in the arch; and third, and ultimately most important, the occlusion of the teeth.

As the retaining device is to be worn for a considerable time, some prefer its construction from gold instead of nickel silver, on account of the tendency of the latter to discolor in some mouths; but it is a fact, which anyone may verify by experiment, that bands of the same delicacy will give far less trouble by loosening if made of nickel silver than if made of gold or silver, or of any other of the alloys, and hence are preferable, at least during the experimental period of retention.

The appliances necessary for retaining the teeth need never be bulky nor complicated, nor comprise a large number of pieces. We must remember that the patient is probably already wearied with the inconvenience of the regulating appliances, so it should be the aim to make the retaining devices as delicate, compact, and inconspicuous as possible, always, however, consistent with the main object—perfect support.

The more securely the teeth are held, the more rapidly will they become firm in their new positions. For this reason, and that they may be as little as possible under the control of the patient, the appliances should be made stationary by the attachment of accurately fitted and cemented bands whenever practicable. They should also be readily cleansible by the patient with the brush, that they may in no way injure the teeth, no matter how long worn. It is remarkable how compact, simple, efficient, and cleanly the retaining devices may be made, even for the most complicated conditions.

The problems to be met in retention are limitless in their variation, and often difficult, and the possibilities for the development of skill are also limitless. We will here suggest only such devices as embody principles which admit of great variation and which have been most satisfactory in the writer's hands.

Retention of Teeth in Cases Belonging to Class I.—As the movement of teeth in cases belonging to Class I has been conducted independent of the mesial or distal positions of the teeth of the opposing arch, a condition met with in cases belonging to Classes II and III, we have here but to consider methods of resisting the movements of individual teeth in each arch, independent of the teeth in the other arch, and usually teeth anterior to the molars only.

Temporary Retaining Devices.—Before adjusting the retaining device, it is often best to allow the regulating appliances to remain passively in position upon the teeth for two or three weeks, in order that all tenderness of the teeth may subside. Yet upon the removal of the regulating appliances there is usually found to be more or less soreness, as well as mobility, in the teeth. It is, therefore, difficult or impossible to form and fit bands with any considerable degree of accuracy without occasioning pain, and pain may and should be avoided. After removing the expansion arch and thoroughly cleansing the teeth, it is best to adjust a temporary device, often with the same form as if it were to be permanent, with looser fit of bands, which may be gently worked into position with the fingers alone. If a good quality of cement be used the device will be firmly held in position for a few weeks, until all soreness shall have subsided, when a device, with bands and all other parts of the most perfect fit and finish, may be substituted. This may be of precious metal if desired.

Another satisfactory plan for temporary retention is to weave strands of the wire ligatures about the teeth, engaging the spurs upon the bands which have been used in effecting the various tooth movements, and in this way antagonizing the teeth in the direction of their tendencies.

This is an excellent method of temporary retention, and one that may often be taken advantage of, as was done in the case shown in Figs. 832, 833, and 834. A wire ligature was made to engage the spurs on the central incisors, both ends brought forward and tightly twisted at the

mesio-labial angles of the centrals. Then another ligature was made to engage the spur on the disto-lingual angle of the left lateral incisor, the ends brought forward across its labial surface, one end being passed between the central and lateral and made to engage the spur upon the left central, brought back between these teeth, and firmly twisted with the other end of the strand of ligature at a point on the labial surface of the lateral incisor, as indicated. In precisely the same manner a third ligature was made to engage the spurs upon the right lateral and central, all as shown in Fig. 833. By studying the original positions of the teeth in Fig. 832, it will be seen how direct and positive is the reciprocal force exerted by these ligatures in resisting the movement of the teeth in the direction of their tendencies.

Fig. 832

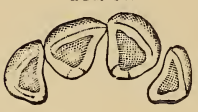


Fig. 833



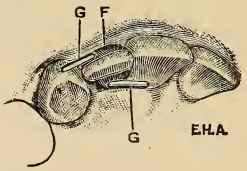
Fig. 834



After a few weeks of temporary retention the teeth were permanently retained, as shown in Fig. 834, by other bands placed upon the laterals and connected by a section of wire in the usual way, as described elsewhere.

Permanent Retaining Devices.—The simple band and the short projecting wire, which for convenience we call a spur, form the basis of a principle which is applicable to nearly all the requirements of permanent retention in all the various classes. It is surprising to find in what number of combinations the band and spur may be employed. If a single tooth has been rotated, it may be prevented from returning to its former position (or antagonized in the direction of its tendency) by a band with two spurs, as in Fig. 835. These may be soldered directly to the band. Unnecessarily long spurs should never be used, as they are cumbersome and unsightly. Even shorter spurs than those shown in the engraving may be employed.

Fig. 835



Much care should be exercised in placing the points of the spurs which bear against the adjoining teeth so that they will not cause displacement of the tooth retained. If placed as shown in the engraving, the elevation of the lateral in its socket would be inevitable, on account of the inclined planes of the adjoining teeth down which the spur will be made to slide by the tooth in its tendency to return to its original position. (This point may be taken advantage of, however, in some cases in which it is desirable to force the eruption of a tooth slightly; for

example, a canine.) The point of the spur in the case shown should bear upon the gingival ridge of the central, while the point of bearing upon the canine should be above the swell of the crown. The fine adjustment of the spurs should be left until the cement has hardened after setting the band, when they may be bent until their ends touch at the exact points required. In some instances in which the period of retention is to be protracted, or where bands would be unpleasantly conspicuous, spurs may be set in fillings, as in Fig. 836. In the case of deciduous teeth soon to be lost, spurs may be cemented in cavities drilled in the enamel for the purpose, in preference to the setting of bands.

A method often desirable when the space of a lost tooth is to be preserved is to insert between two bands on the approximating teeth a short section of wire, *G*, its ends being engaged in tubes *R* soldered to the bands, as in Fig. 837. This wire may be lengthened, if it is desired to increase the space, by pinching it with the regulating pliers.

Fig. 836

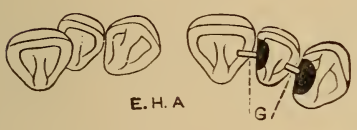
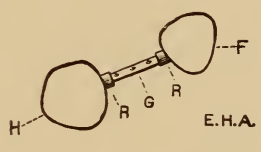
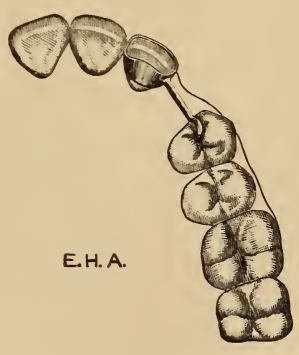


Fig. 837



Another excellent modification of this plan is shown in Fig. 838, in which one band is dispensed with, one end of the section wire *G* being bent in the form of a goose-neck to engage the mesial surface and sulcus of the first premolar, the other end being soldered directly to a plain band on the lateral incisor. If two approximating teeth have been rotated in opposite directions, the firmest support is given them by encircling each tooth with a band, across the labial surface of which a section of wire is soldered—practically two bands and spurs united. The spring of the spur makes possible a greater precision in the adjustment of the bands, with less liability of subsequent loosening, than when the bands are united directly by solder.

Fig. 838



The tendency to rotation of the right central and lateral incisors, plus the lingual tendency of the left central and the mesial tendency of all, is effectually resisted by two bands connected by a spur, with an additional spur made to bear upon the mesio-labial angle of the right lateral, as in Fig. 839. The engraving shows the ends of the wire G, secured by engaging tubes soldered to the

lingual surfaces of the bands. Direct attachment of the ends of the wire to the bands by solder may, of course, also be used, and is preferable. By studying the tendency of the teeth, it will be seen how effectually they are resisted by this device.

Fig. 839

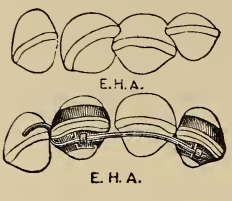


Fig. 840

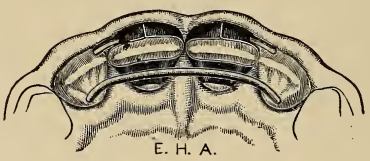


Fig. 841



Fig. 840 shows the union of two bands by a section of wire G, employed to antagonize the lingual tendency of two lateral incisors which have been moved labially into the line of occlusion, while another com-

Fig. 842



bination of bands and spurs (Fig. 841) attached to the centrals would accomplish the same result. The former device is more efficient, but less esthetic than the latter.

Fig. 843

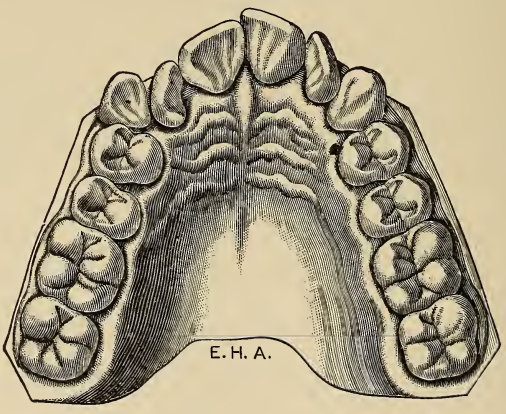


Fig. 842 shows a combination of bands and spurs of great simplicity used to resist the tendency of the incisors to return to their original positions, which are shown in Fig. 843.

Neatly fitting bands upon the central incisors are connected on their

lingual surfaces by a section of the wire G, the ends of which project and bear against the disto-lingual surfaces of the laterals, while two spurs are soldered to the disto-labial angles of the bands on the central incisors and bear against the mesio-labial angles of the laterals. This is probably the simplest possible device for resisting these movements. It is impor-

FIG. 844

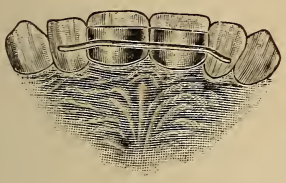
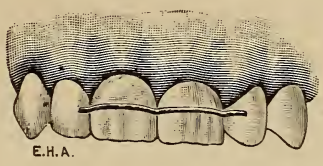


FIG. 845



tant that it be adjusted with accuracy, and also that the ends of the wire be carefully placed, for reasons given in connection with the description of Fig. 835. In some instances it may be an advantage to provide a suitable resting place for the lingual spurs by slightly grooving the marginal ridge of the laterals.

Dr. Jane Bunker has ingeniously modified this device, as shown in Figs. 844 and 845, in which a section of wire is soldered across the labial sur-

FIG. 846

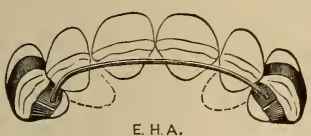


FIG. 847

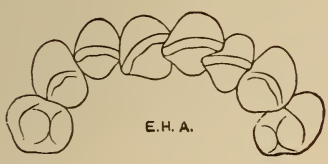


FIG. 848

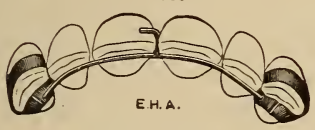
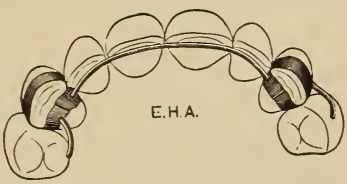


FIG. 849



FIG. 850



faces of the two bands on the centrals, after which all of that portion of the labial surface of the bands above and below the spur is carefully cut away, so that the wire only is in evidence.

Two lingual spurs engage the laterals.

This plan of removal of a portion of the band may be variously

applied, and where efficiency is in a degree sacrificed for esthetics, the device will be found sufficiently firm as to make its use often desirable. It should be remembered that its weakest point is where the band emerges between the teeth to join the wire. It should be properly strengthened at this point with solder.

Another very useful plan for accomplishing the same result is to solder a section of wire G, directly to the labial surface of a band on each lateral, the ends being made to rest against the labial surfaces of canines and centrals.

FIG. 851

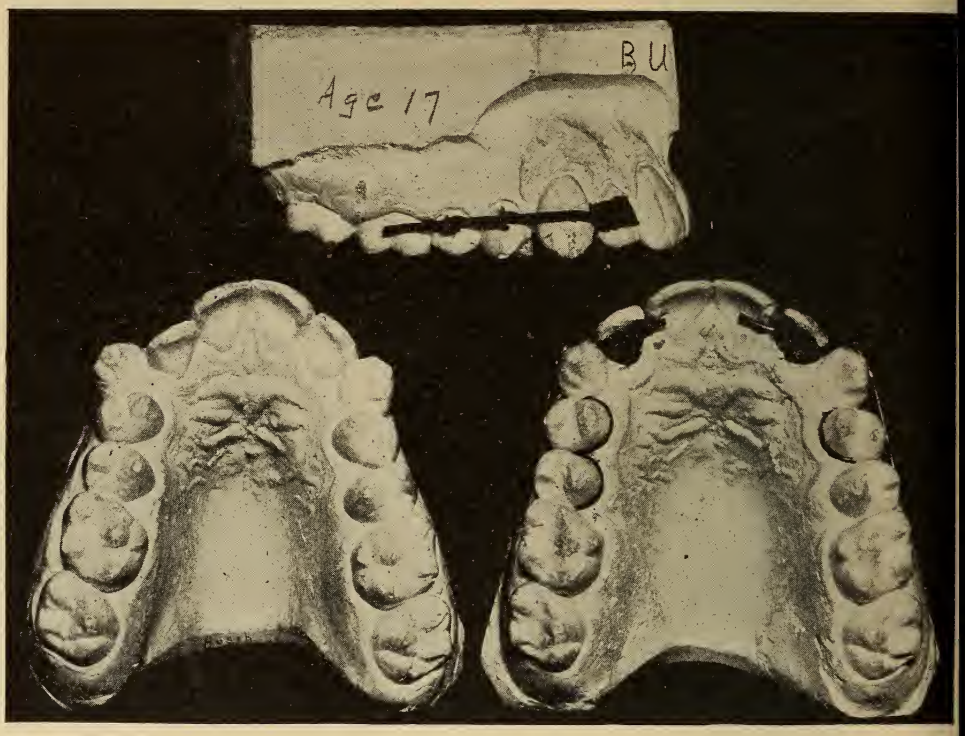


Fig. 846 shows the union of two bands by a section of wire G, which would not only accomplish the same result, but would also resist lateral pressure or rotation of one or both of the canines if required, while an additional spur, as in Fig. 848, would antagonize the tendency of the central shown in Fig. 847.

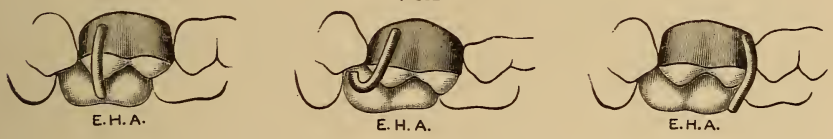
By the addition of two spurs to this combination, as in Fig. 850, the lingual and buccal tendencies of the first premolars are also resisted in the more complicated case shown in Fig. 849.

Another very simple but very efficient plan of retention is shown in Fig. 851. Bands are placed on the lateral incisors, each provided with a short spur which engages the disto-lingual angle of the centrals, and two long spurs, soldered at the disto-labial angles of

the lateral bands, bear heavily upon the canines as they pass distally to be engaged by wire ligatures encircling the premolars. Thus, the proper width of the arch, as well as the positions of the incisors and canines, are maintained. This is a favorite device with the writer, and is susceptible of many variations.

It will be seen that any or all of the incisors and canines may be firmly supported by combinations of the band and spur, and that the premolars and molars may be included by extending the principle, but

FIG. 852

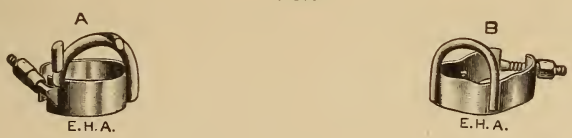


its greatest usefulness is limited to the incisors and canines, or at most extended to include the first premolars. If, however, a single premolar shall have been rotated, or if a single molar or premolar shall have been moved lingually or bucally, the band and double spur made to bear against the adjoining teeth, the same as already described for retention of an incisor, will be most efficient.

In the use of all bands in retention we would caution that they be inspected at least once in two months, for if they should become loosened they would act as receptacles for food particles, the fermentation of which might in time injure the enamel.

A very simple and efficient retaining device for upper molars that have been moved from lingual occlusion, and for lower molars that have been moved from buccal occlusion, as in Figs. 872 and 877, is a band and spur placed upon the upper molar, the spur or finger being made to

FIG. 853



bear against the incline of the buccal surface of the lower molar, or the mesial or distal angle of a lower molar or premolar, shown in Fig. 852. Not only is this device efficient as a retainer, but it is also valuable as a regulating device, for by occasionally bending the spur to increase its efficiency, the buccal movement of the upper molar and the lingual movement of the lower may be accomplished to any desired distance, or they may to some extent be shifted mesially and distally by so placing the spurs as to exert a mesial or distal influence.

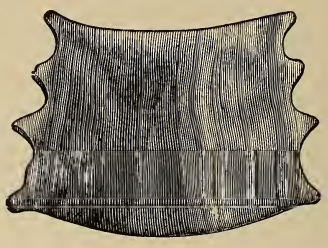
The spur may also with advantage be made in the form of a staple

in some instances, as in *B*, Fig. 853, as its double attachment to the band insures greater strength.

The union of band and spur should be reinforced with plenty of solder and only the best quality of band and cement used.

When a number of the molars have been moved buccally, a metal or vulcanite plate for their retention, as illustrated in Fig. 854, has long been a favorite with many. Its greatest objection, as with all removable retainers, is the uncertainty of its being worn by the patient. The lingual arch, for the same purpose, is preferred by many. It should be elastic, and to avoid injury by heating should be made of iridio-platinum or some of the combinations of precious metals.

Fig. 854



There are many ways of attaching it, two of which are shown in Figs. 855 and 856.

Still another manner of using the lingual arch, which, especially during the latter stages of retention, has become a favorite with the writer, is shown in Fig. 857. It is made in three sections and soldered to the ends of screws of clamp-bands which latter are afterward cemented

Fig. 855

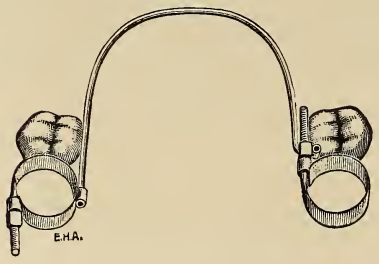
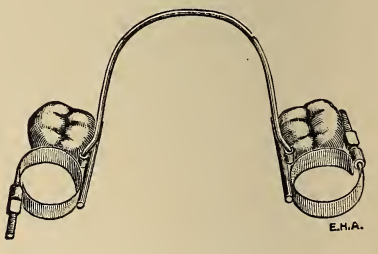


Fig. 856



and clamped upon the molars. Delicate spurs of soft wire may be soldered to the lingual wire, then passed through the interproximal spaces between the incisors and bent to bear against the angles of these teeth to prevent their rotation, and then clipped off. Or, the incisors may be supported by bands, spurs, and ligatures which engage them with the lingual segment of the arch.

In the very great tissue changes that have taken place in all such cases as the one described on page 732 (Huning), it must be apparent that there is a vast amount of tearing down of bone by the osteoclasts, and its rebuilding by osteoblasts, as well as similar cellular and structural changes of the other tissues involved. Very naturally, and a fact proved by experience, these changes are most active and the growth of bone

FIG. 857

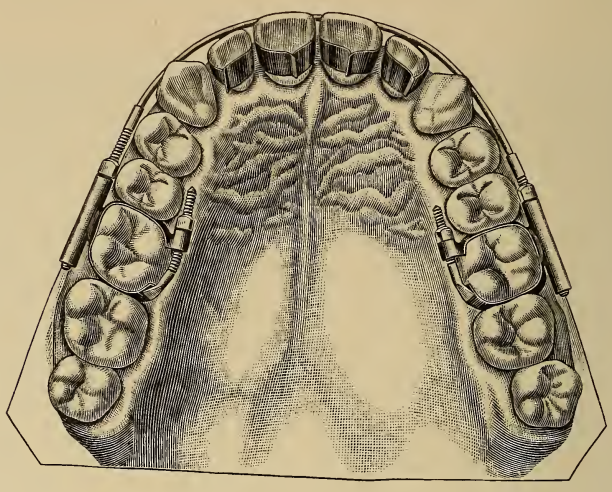


most pronounced in cases treated during the active period of growth and development of the dental apparatus, this activity naturally diminishing with the advancing age of the patient, necessitating longer periods of retention as the patient nears maturity, and after maturity the development is very slow and probably never complete.

With a view to expediting the treatment of malocclusion, by shortening the period of retention in these cases, the writer has devised a

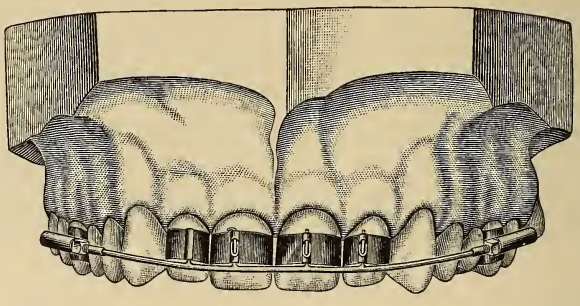
method of retention by which he believes the cells involved in these tissue changes will be gently stimulated to greater activity, with the more speedy and complete development of the tissues.

Fig. 858



The device is shown in Figs. 858 and 859, and is for the purpose not only of supporting the crowns of the teeth in their corrected relations with the line of occlusion, but also to exert a very gentle but constant force

Fig. 859



labially upon the roots of the incisors. It may be regarded as a "working retainer," as appropriately named by Dr. George B. Palmer.

The device is made by removing the segment between the threaded ends of the expansion arch that was employed in accomplishing the

movements of the teeth, and substituting for it a segment, of the same length and curve, of very delicate and elastic wire of precious metal, attaching the ends of this wire to the threaded ends of the original arch with 22 k gold solder.

Small tubes are soldered perpendicularly to the labial surfaces of delicate iridioplatinum bands previously very carefully fitted to the crowns of the incisors. These tubes must be parallel with each other, with their incisal ends resting in contact with the middle segment of the arch.

Very delicate spurs, of the length and diameter of the bore of the tubes, are soldered to the arch at points opposite the mouths of the tubes and at angles exactly corresponding to the bore of the tubes when the arch is in position. The ends of the spurs are then gently inclined

Fig. 860



forward about one-sixteenth of an inch by bending, the arch replaced upon the teeth, and the spurs sprung into the tubes. Thus, a gentle force from the elasticity of the spurs and arch is given to the roots of the teeth in a labial direction, while the crowns are given stationary support in all directions. The spurs are prevented from accidental displacement by filing a hook-like notch near the end of the spur which engages the end of the tube when sprung in position.

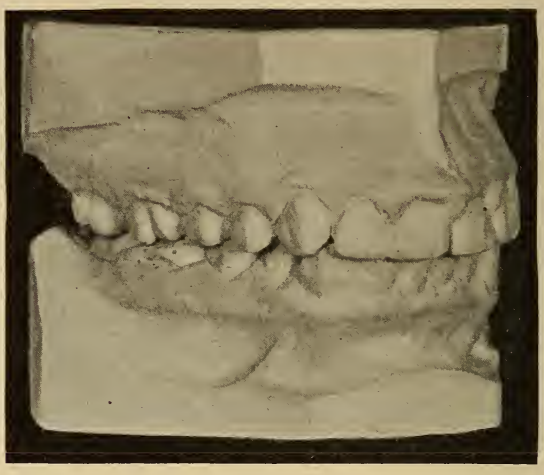
The writer believes that such a gentle, harmless stimulus is thus given as will accelerate cellular activity and greatly lessen the time usually necessary for bone growth and retention, besides effecting final results in bone development which would otherwise be impossible when the patient is nearing maturity.

The importance of the device has been verified in a case reported by Dr. A. H. Ketcham (Fig. 861), which shows the result in bone

growth after six months' wearing of the device, Fig. 860, showing the alveolar process at the time the device was adjusted.

As the alveolar process is developed and the apices of the roots of the teeth are moved labially, it is occasionally necessary to renew the force by further outward bending of the spurs, and, in order to avoid the necessity of removing the arch and the possible accident of its unfavorable bending, the writer recommends that a portion of the centre of the tubes be removed with a round file, as shown in the engraving. The arch may then be sprung slightly downward, the ends of the spurs caught with a delicate excavator where the tubes are cut away for the purpose, and given the necessary bend, then the spurs sprung back into

Fig. 861



position. This, however, should not be done oftener than once in one or two months.

By studying the possibilities of this device it will be seen that we have absolute control over the development of the positions of the teeth in their entirety—far more so than by the use of any other known device:

First, the most perfect support is given to the crowns of the teeth in all directions.

Second, the crowns may be shifted labially or lingually, by tightening or loosening the nuts in front of the tubes of the anchor bands.

Third, the positions of the roots of the teeth may be developed labially or lingually, mesially or distally, by gentle force from the proper bending of the spurs, independent of the position of the crowns.

Fourth, force for rotation or for the prevention of rotation of any of the teeth may be given by partially flattening the ends of the delicate spurs and the ends of the tubes in which they are engaged, then giving the spurs a slight twist, and respringing them into position.

And finally, all of the teeth may at the same time be lengthened, if so desired, by giving the necessary downward spring to the segment of the arch.

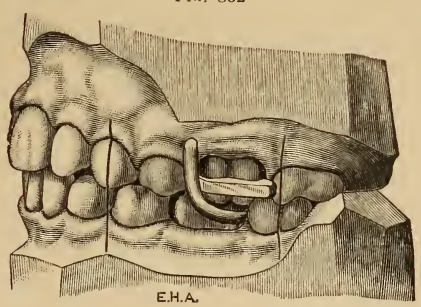
In like manner, support and movement may be given to the canines and premolars, if desired, and, by drilling through the sheaths of the tubes of the anchor bands and the sides of the threaded portion of the arch and inserting delicate keys therein, force may be exerted through the elasticity of the arch for the movements of the molar roots, either buccally or lingually.

In making use of this device the arch may be placed above the tubes instead of below them, as shown, or, in favorable cases where the occlusion will permit, the arch may be placed lingually to the teeth, with the tubes either parallel with or at right angles to the long axes of the teeth. But, all things considered, the position given the device in the engraving will be found to be the most satisfactory.

It is also equally applicable to the lower dental arch.

This device may be operated either as a regulating or retaining appliance, or both, as its name implies. The writer believes its greatest usefulness will be as a bone stimulant, and when so used should be made very delicate, as described, so that only such gentle force will be given to the roots of the teeth as will physiologically stimulate the bone cells. Great force and rapid movement of the apices of the roots of the teeth the writer believes to be unphysiological.

FIG. 862



Retention of Cases Belonging to Class II.—In the retention of cases belonging to Class II the principal problem is to resist the mesial movement of the teeth of the upper arch and the distal movement of those of the lower arch, especially the canines, premolars, and molars. If there have been movements of individual teeth in other directions, as torsally, labially, etc., their movements may be resisted by methods which we have previously described for the retention of teeth in cases belonging to Class I.

Our principal reliance is the application of force reciprocally between the teeth of opposing arches by means of intermaxillary retainers, shown

in Fig. 862. This retainer is susceptible of numerous modifications to meet the requirements in different cases.

It consists of a strong spur made to close in front of a plane of metal, both soldered to No. 2 bands, which are clamped in cement on opposing molars.

The plane of metal, best cut from a silver ten-cent piece, should be about one-fourth of an inch long and one-eighth of an inch wide, and rounded on its distal angle.

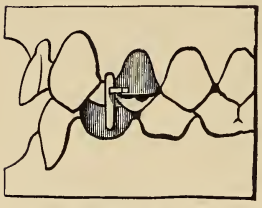
The spur is best made of nickel silver, about three thirty-seconds of an inch in diameter.

The stress upon this device is often very severe, and unless carefully made and properly cemented upon the teeth it will give trouble by loosening.

Bands of the best quality should be carefully fitted to the molars, and at their union with plane and spur should be strongly reinforced with plenty of solder, care being taken not to weaken the bands by overheating.

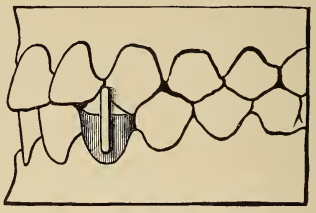
Both bands should be placed as near the grinding surfaces of the crowns of the teeth as possible, without interfering with occlusion, and the plane attached low down, or at the very edge of the upper band, and the spur attached as high up as possible on the lower band. In this way the spur is shortened and the leverage decreased, with the consequent danger of loosening minimized. The spur should always engage the plane on an incline, as shown in the engraving. It may occasionally be necessary to shift the position of the plane mesially or distally by resoldering to meet the requirements, as retention progresses.

FIG. 863



E. H. A.

FIG. 864



E. H. A.

FIG. 865



E. H. A

This method of intermaxillary retention is also applicable to premolars and canines, as shown in Figs. 863 and 864. It may be used on these teeth in connection with molar retention, or independently, as occasion may require. It is often desirable to alternate from one to the other. The device as shown in Fig. 863 is incorrect, the spur shown. as being perpendicular instead of engaging the plane on a slight incline.

When made use of upon the canine teeth no band or plane of metal is needed on the opposing (upper) canine, as the mesial incline of the

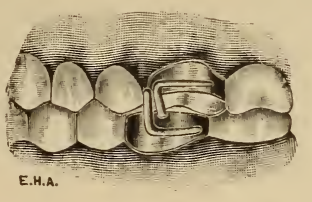
cusp of this tooth is taken advantage of. The flat spur should be grooved on its edge to make more secure its relation with the upper canine.

It should incline somewhat forward to be most effective, and if occasional adjustment is necessary, this may easily be done by bending, to make its bearing upon the upper canine more effective. In this way not only retention, but the actual movement of the upper canine distally and the lower canine mesially, may be accomplished to some extent, and in many cases this is very desirable.

Owing to the unfavorable shape for banding of the lower canine tooth, there is more liability of bands upon these teeth loosening under strain than those upon the premolars. They should therefore be made with the greatest care, always using H band material, and securing the most perfect fit. This spur is also best made from a silver ten-cent piece. The band is illustrated in Fig. 865.

In rare instances spurs set in fillings for accomplishing the same purpose in retention will be found desirable, and Dr. Stanton makes use of a crown covering a tooth, which is fitted with an inclined plane at the desired point to engage the opposing cusp. The device would be efficient and especially applicable to the deciduous teeth, where the necessary reduction of the crown of the tooth in order to properly fit the metal cap would be permissible.

Fig. 866



The writer's plan of intermaxillary retention has been ingeniously modified by Dr. Grünberg, as shown in Fig. 866, and as in the use of this device the strain upon band and spur is quite equally divided, it will undoubtedly prove very efficient.

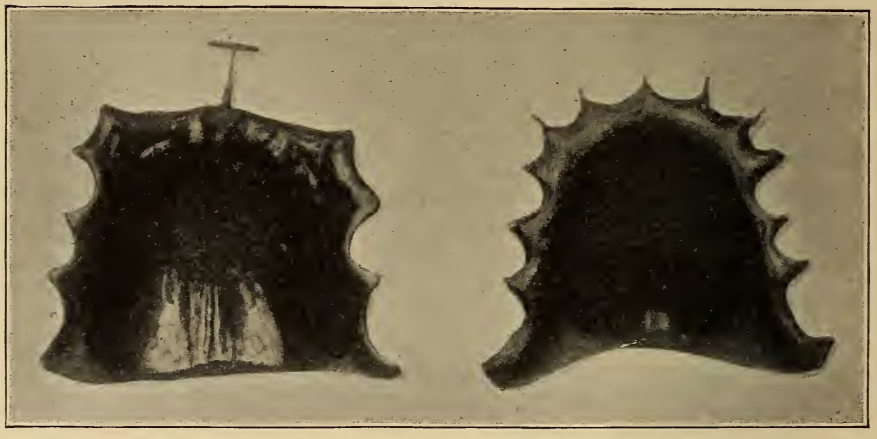
For maintaining the proper width of the upper dental arch in the region of the premolars and to prevent the labial movement of the incisors which have been moved lingually in cases belonging to Division 1 of Class II and its subdivision, the lingual wire arch, shown in Fig. 857, is a favorite with the writer, in these cases taking advantage of the molar clamp bands that bear the planes of metal. The lingual arch here serves also another purpose, giving additional support to the molars.

Very delicate gold bands encircle the incisors. They are provided with delicate hooks or staples on their lingual surfaces for securing their attachment to the arch by means of wire ligatures. The writer

employs this means of attachment of the incisors in preference to the immediate engagement of the arch to the bands by solder, tubes, or spurs, as it admits of an easier adjustment and better control over the positions of these teeth, although some prefer hooks or staples soldered to the bands which directly engage the arch. Still, in many instances the writer prefers the simple wire ligature alone for securing the incisors to the arch, making the twist of the ligatures lingually to the teeth.

Another plan, given to us by Dr. Kingsley, which has long been a favorite with many, is by means of a neatly fitting vulcanite or metal plate which covers the vault of the arch, shown in Fig. 867. This prevents the narrowing of the arch and also provides a means for the support of a screw in its anterior part. The screw is beaten thin where it passes between the central incisors, and is provided with a small button or cross-bar soldered to the end of the screw which is made to bear against

FIG. 867



the labial surface of the two central incisors. This is an efficient retainer, but the danger of its not being worn constantly by the patient makes its use far less desirable than that of a fixed device, yet it has long been a favorite with the writer in the last stages of retention. When used in connection with intermaxillary retention, the plate must be freely cut away to avoid interference with the screws of the clamp-bands.

The working retainer, described on page 800 (Figs. 858 and 859), may also be used with much satisfaction for retaining the incisors in some cases belonging to this class.

A device which may occasionally be used to advantage for resisting the labial and lengthening movements of the upper incisors is effected by placing upon the lower central incisors plain bands, having soldered to their labial surfaces strong spurs which project forward and are bent upward sharply at right angles to engage the labio-occlusal edges of the upper incisors, as shown on one tooth in Fig. 868. The stability

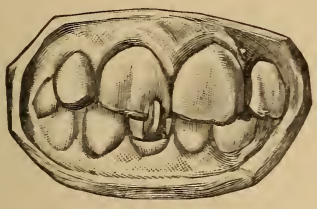
of the teeth used as anchorage should be reinforced by a section of the wire G, soldered across the lingual surface of their bands and made to bear against the adjoining lateral incisors.

Sometimes it may be desirable to place the bands upon the canines instead of upon the incisors, and connect them by a bar of metal containing the retaining spurs, Fig. 869.

If the reader will study this device he will observe that in its use not only is normal closure of the jaw compulsory, but that the incisors are kept compressed in their sockets and prevented from moving labially as well. Still another advantage of no small importance is gained in preventing the lower lip from being drawn against the lingual surfaces of the upper incisors, a habit which seems to be almost universal in these cases, and difficult but most necessary to overcome.

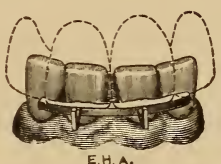
For the second division of Class II and its subdivision the plan of retention for the molars, premolars, and canines is the same as that already described for the retention of these teeth in Division 1, Class II, and its subdivision.

FIG. 868



E. H. A.

FIG. 869



E.H.A.

As the upper incisors in Division 2 are usually more or less crowded, rotated, and retruded in their relation to the line of occlusion, their requirements for movement, as well as the problems in their retention, are practically the same as for cases in which these teeth occupy similar malpositions in Class I. So their movements are readily combated by similar combinations of bands and spurs, as are also the anterior teeth of the lower arch. The working retainer may also be used in these cases, especially when there is found to be lack of development of the bone in the region of one or more of the incisors.

Retention for Cases Belonging to Class III.—As in Class III the movements of the molars, premolars, and canines of both arches are the reverse of the movements of these teeth in Class II, the same plan of ntermaxillary retention, with the direction of force reversed, is employed, the spurs on the lower molars operating against the distal ends of the planes on the opposing teeth. It is frequently advisable to place the spur on the upper molars and the plane on the lower, in which case the spur operates against the mesial end of the plane. Dr. Grünberg's excellent modification of the plane and spur, previously described, will also be found very applicable.

The same results may be accomplished in simple Class III cases of very young patients by means of plain bands carefully fitted to and cemented on the upper central incisors, the bands having spurs soldered to their lingual surfaces which project downward and forward to engage the labial surfaces of the lower incisors, thus compelling the normal closure of the jaw and normal mesio-distal relations of the teeth.

When individual movements of any of the anterior teeth have been accomplished they are retained by the application of bands and spurs in some of their combinations, as would be employed in similar problems found in Class I.

The application of these principles of retention will be further discussed in the treatment of individual cases.

TREATMENT

Preliminary Considerations.—Before beginning treatment of malocclusion of the teeth there should be certain well-defined principles fixed in our minds in regard to the dental apparatus as a whole, for we must constantly bear in mind the intimate relations existing between the teeth and all other tissues and parts of the dental apparatus, and the powerful influences they exert upon one another. We have seen that nature builds the human denture in accordance with her long-tried and well-established laws, the result being a constant and well-defined pattern; that this pattern, although varied in form, is in principle always the same; and that its variations are always in harmony with the demands of the type of the individual.

We have already noted that when nature, through certain adverse causes, is unable to fully carry out her normal processes in the building of the dental apparatus, there are in the result defects or variations from the normal plan, shown in malocclusion of the teeth, with consequent impairment of their functions—the extent of the malocclusion being in direct proportion to the extent of the disturbing cause—the perversion of the forces which are operative in building the normal denture. Also, in the same proportion as malocclusion exists, will there be disturbance in the harmony and balance of the mouth with the rest of the face.

The longer teeth remain in malocclusion the more fixed becomes the variation from the normal in all co-related muscles and tissues. Logically, then, in the treatment of malocclusion our attention should be directed toward interpreting nature's designs and assisting her to carry out her original plan in the building of the denture, working hand in hand with her, for only as we comprehend her intent in each individual case and assist her, will our efforts be successful in establishing the normal in occlusion and the normal in the balance of the mouth with the rest of the face. It should be obvious, then, to all thoughtful minds,

that the demand in treatment is the removal of pernicious causes, the retention of the full complement of teeth, and the compelling of their normal locking during or subsequent to their normal period of eruption, thus permitting nature to complete the denture and the co-related parts according to her fixed plan and the demands of the individual type. It is also obvious that the earlier our efforts at treatment are begun, the better we will be able to assist nature, and the more satisfactory will be the results.

The method so long followed of determining an arbitrary course of treatment for each individual case "according to the judgment of the operator," in which extraction is freely resorted to, and the sizes of arches greatly reduced and their forms modified from nature's intended plan and the demands of the type, has ever resulted, and can only result, in establishing the abnormal—deformity. By such treatment, instead of greater freedom being given to the tongue and normal function to the teeth, the former is often more restricted and the function of the latter upon the whole rarely improved; and instead of establishing balance, harmony, and beauty of the facial lines, the deformity is ultimately more often found to have been only modified, with a result even far less pleasing than the original condition.

While in most instances we may rapidly establish the normal sizes of the arches and relations of the teeth, much time will often be required by nature to effect the normal development of the other tissues of the dental apparatus, the development of which has been arrested. Yet even in this we may often greatly assist nature by directing our patients as to the proper and necessary closure of their lips and teeth, and proper breathing, and by insisting upon their overcoming pernicious habits of the lips and tongue, and also insisting upon treatment of nose and throat when needed. These conditions often call for much tact and persistent patience on the part of the orthodontist.

What we have said presupposes the treatment of cases with the full complement of teeth, which we have had the opportunity to treat during their most active period of growth, development, and eruption, or during the period in which lie our greatest opportunities for assisting nature in approximating the nearest to the ideal in the results. Yet many cases are presented for treatment in which there is a lack of the full complement of teeth, through failure to develop, extraction, or caries. The demands for the great object to be accomplished, however, are the same in these cases as when the full complement of teeth is present, and necessitates the establishing of normal occlusion, or as nearly so as the exigencies of the case will permit, by enlarging the dental arches to their normal size and replacing the missing teeth by artificial substitutes. While this ideal treatment may not always be deemed advisable, it is impossible to lay down any rules for such exceptions.

The carrying out of the ideal in the treatment of such cases presents

such apparently great difficulties that it would probably be the last one to which the amateur in orthodontia would naturally resort. He would be inclined to compensate for the already diminished size of one arch by reducing the size of the opposing arch by extraction. Yet the great difficulty of permanently maintaining the teeth in correct alignment when so treated must not be lost sight of, for it must be remembered that inclined occlusal planes, inharmonious as to size and form, are thus brought in contact, with teeth, also, at incorrect angles of inclination, thus tending toward their displacement from wrongly distributed force in occlusion, instead of occlusal planes harmonious as to size and relation with normal angle of inclination of teeth, as intended by nature, which favors permanency of normal positions and relations. Moreover, by the reduction of the sizes of the dental arches, the tongue and lips must exercise less control in keeping the teeth in correct positions than when exerting their full normal influence, as when the full number of teeth is correctly placed. Furthermore, the invariable detrimental effect on the facial lines, the shortening of the bite, and the impairment of speech, make this plan of treatment so objectionable that it is rarely, indeed, that the skilful, modern orthodontist would resort to it, for the great perfection to which the regulating appliances have been brought makes easily possible the enlarging of the dental arches and the regaining of the spaces for the full mesio-distal diameter of malposed or missing teeth. This fact, together with the ease and permanency with which missing teeth are replaced, owing to the great advancement in modern prosthetic art, makes this the one plan of practice that will be more and more appreciated by the true orthodontist as his knowledge and experience increase; yet in the cases of very young patients, where there has been mutilation, it is often difficult to decide which of the two plans to follow, the serious problem hinging upon the result of mutilating sound teeth in order to restore missing teeth by artificial substitutes. Still, if it were always possible to have these restorations made with a very high degree of skill, with mutilation reduced to the minimum, the conservative, ideal plan of treatment would be universally desirable.

Treatment of Cases.—Class I.—As we have already noted in the classification of malocclusion, the number of cases belonging to this class is the greatest and comprises by far the largest variety, the distinguishing characteristic of the class being relative normal relations of the jaws, with molars in correct relation mesio-distally, although one or more may be in buccal or lingual occlusion. The malposed teeth are usually, however, confined to those anterior to the molars, and more commonly to the incisors and canines, the dental arches being smaller than normal and the teeth crowded and overlapping. Both arches are usually involved, and sometimes quite similarly.

As the mesio-distal relations of the lateral halves of the dental arches

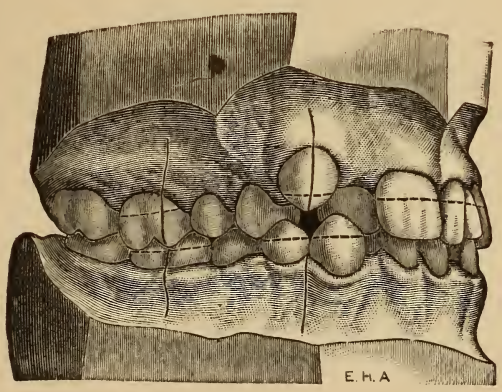
are normal in this class, it must follow that, if the malposed teeth of each arch be moved into harmony with the line of occlusion, the arches must then be in perfect harmony as to size, with harmony of the occlusal inclined planes of the cusps—normal occlusion—and with proper facial balance established. The latter, however, may not at once be apparent, as we shall see later, but it must follow ultimately when nature shall have effected the full development of the alveolar process and the muscles shall have become modified in form and function so as to act normally in their relation with the teeth in occlusion.



E. H. A.

To illustrate, Fig. 870 represents a type of malocclusion which, in its variations, is common in this class. It will be seen that the mesial and distal inclined planes of the mesio-buccal cusp of the upper first molar on the right are received between the inclines of the mesio- and disto-buccal cusps of the lower first molar, or that the relations of the first molars are normal. (The molars of the opposite side were also in normal relation.) The arches are diminished in size, and the teeth, especially the incisors, occupy positions lingual to the line of occlusion. What is then clearly indicated is that the arches should be enlarged and each tooth moved into its correct position in the line of occlusion, as shown in the case when completed (Fig. 871), and in the plan of treatment of any case, as has been said, it makes but little difference what positions the malposed teeth may occupy, they are always subject to

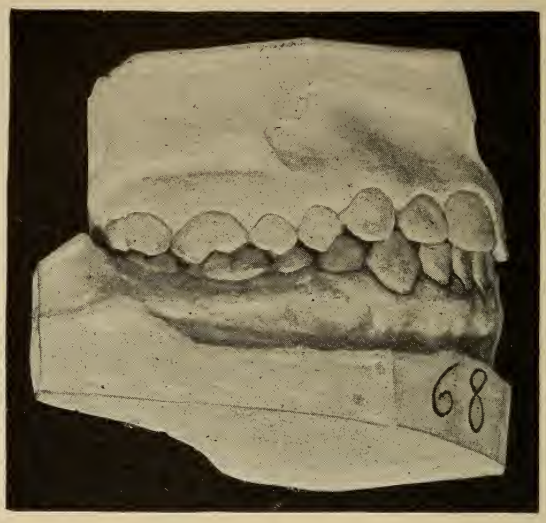
FIG. 870



the same general requirement. In the completed case, as shown in Fig. 871, it will be seen that each tooth has been placed in harmony with the line of occlusion, and is, therefore, now in best position to support and be supported by all the remaining teeth, as well as to be in best harmony with the muscles and to make possible the normal balance of the facial lines.

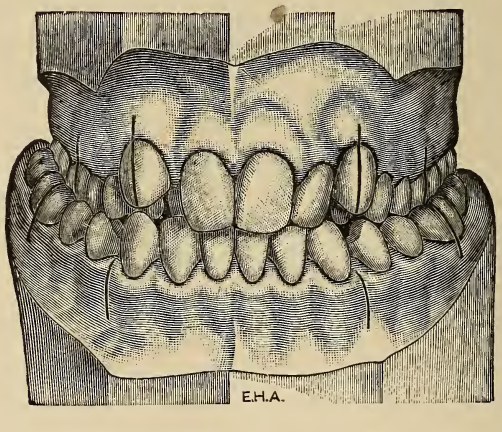
Fig. 872 shows one of the most complicated types of cases belonging to this class. The teeth of both lateral halves of the upper arch are in lingual occlusion, the upper arch greatly narrowed and diminished

Fig. 871



in size, with the laterals in marked torsolingual occlusion, and the centrals in torsal occlusion, while the great force received upon the molars, being wrongly distributed, has resulted in displacing all the buccal teeth of the upper arch bodily lingually, the apices of the roots as

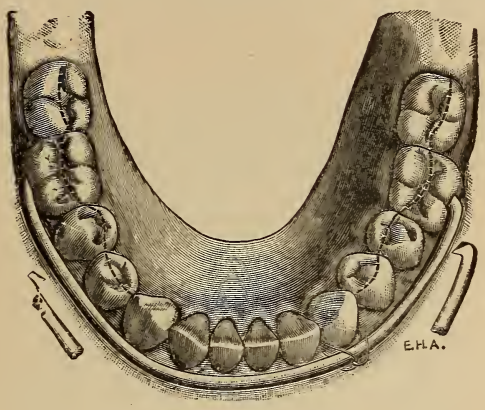
Fig. 872



well as the crowns, with the opposite effect on the opposing teeth, thus greatly narrowing the upper jaw, dental arch, and nasal space, and widening the lower jaw, giving a peculiar bagginess to the lower part

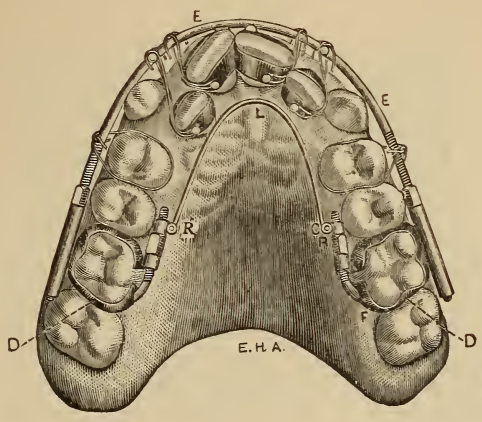
of the face always noticeable in these cases. They are always progressive, usually beginning with the mal-locking of the first permanent molars, but sometimes preceded by similar malocclusion of the deciduous teeth.

Fig. 873



Had the first permanent molars received but a few hours' attention on coming into occlusion and been compelled to take their normal relations, doubtless the malocclusion would have ended there, and the eruption of the teeth and development of the alveolar process subsequent to this

Fig. 874

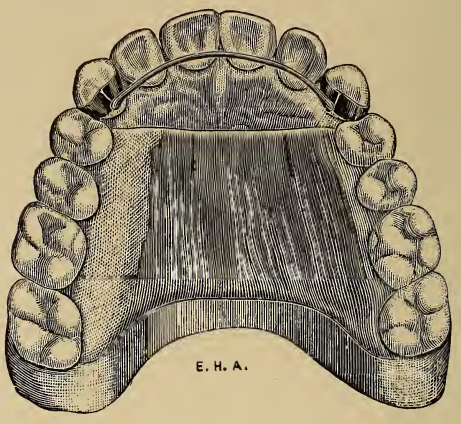


would have been along normal lines. Yet many dentists still persist in advising parents to defer treatment of their children's malocclusion until all of the teeth have erupted.

The line of treatment was toward the ideal, widening the upper arch, correcting the malpositions of the incisors, and narrowing the lower arch.

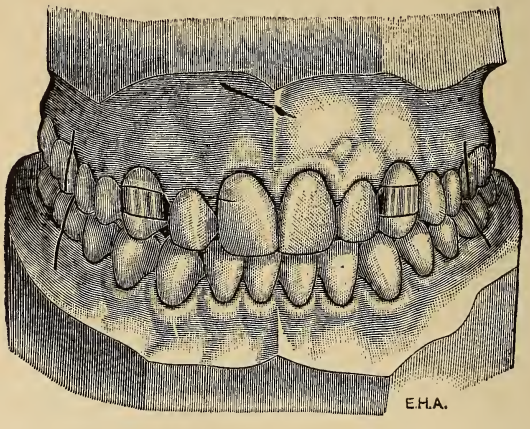
Fig. 874 shows the upper arch being widened by means of the expansion arch, adjusted in the usual way, and reinforced by one of the spring levers, *L*, the incisors being moved forward *en masse* and rotated by means of spurred bands, ligatures, etc., all as shown and described in the section on Adjustment and Operation of Appliances.

Fig. 875



The narrowing of the lower arch was effected by means of a device manufactured for the occasion and shown in Fig. 873; but the recent practice of the writer is to narrow the dental arches in such cases with the expansion arch (ribbed), it having been found that it develops ample force for this purpose.

Fig. 876

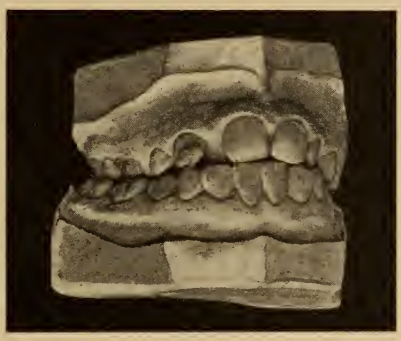


In making use of the ribbed arch, as above, it is only necessary to compress its sides so that they are perhaps two-thirds the width of the dental arch to be narrowed, and insert the ends in the sheaths of the D bands, as usual, care being taken to retain all of the spring in the

lingual direction possible. The arch is prevented from springing forward by being secured to the incisors by one or more ligatures. Although its action is slow, requiring several weeks in a patient, aged sixteen years, the writer has found its use most satisfactory.

Fig. 875 shows the upper arch completed and the retaining devices in position, while Fig. 876 shows both arches completed and the teeth

FIG. 877



in occlusion. The lingual tendency of the upper incisors and the torso-infra-occlusal tendencies of the upper canines, as well as the lingual tendency of the molars and premolars, were resisted by bands on the canines connected by a section of the wire G, and a vulcanite plate, as illustrated. The bands upon the canines are also shown in Fig. 876.

FIG. 878



As here shown, the retaining wire rests on the incline of the lingual marginal ridges of the incisors. It should bear either above or below this incline, for if allowed to rest in the position shown, delicate bands would be required on the laterals, at least, to prevent the wire from being forced toward the cutting edges of the teeth.

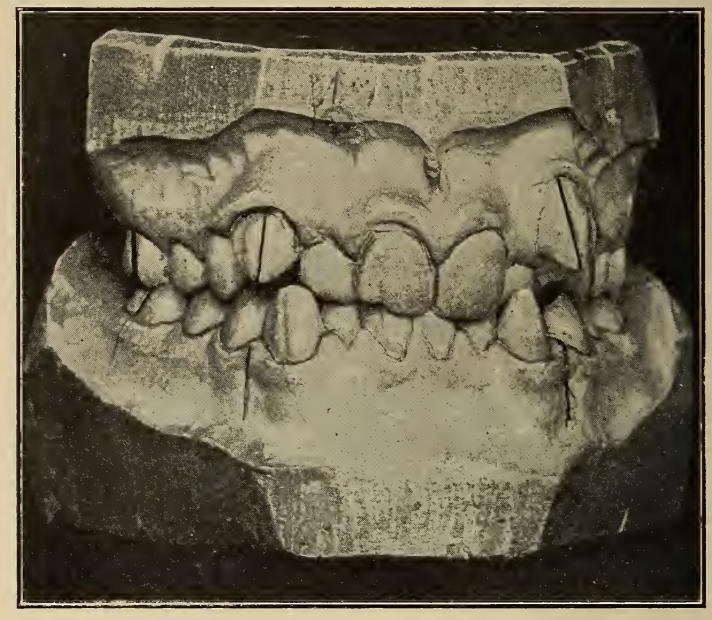
The lingual retaining arch, as shown in Fig. 857, would often be preferable to the bands and plate in such cases, and the working retainer

might also be used, and doubtless in many similar cases would be preferable.

The model illustrated in Fig. 877 represents a case where one only of the lateral halves of the upper arch was in lingual occlusion. The lateral incisors were in marked torso-lingual occlusion. The patient was a child, aged eight years, the deciduous molars and canines being still in position.

The plan of treatment clearly indicated was widening the arch by movement buccally of the teeth on the affected side only, with labial movement of the centrals and torso-labial movement of the laterals. Fig. 878 shows a view of this arch from the occlusal aspect, with the appliances for accomplishing these movements of the teeth in position.

Fig. 879



It will be seen that all of the teeth on the left side are used as anchorage, and that their combined resistance is concentrated, through the force distributed by the external and internal arches, upon the left first permanent molar. But a few days were necessary to move this tooth into correct position, where it was maintained by occlusion and the modified (through bending) alveolar process. A wire ligature was then made to encircle the second deciduous molar and the expansion arch, thus practically transferring the force to this tooth. Later, the first deciduous molar was moved out in the same way. The object of moving the teeth one at a time was to avoid overtaxing the anchorage derived from the opposite side of the arch. Had the effort been made to move all at the

same time, it is probable that the teeth on the normal side would have been displaced more rapidly than those on the abnormal side, on account of the increased resistance offered by the inlocking of the inclined planes of the cusps of the molars on the abnormal side. The writer's latest plan for avoiding displacement of the teeth used as anchorage in cases of this kind is to enlist stationary anchorage by uniting the sheath of the clamp-band and the threaded portion of the

FIG. 880



arch within it with soft solder, thus requiring the displacement of the anchor tooth bodily, if moved at all. It will be readily understood how greatly the anchorage would be thus increased.

While the appliances were acting upon the abnormal lateral half of the arch, the incisors were carried forward and rotated by bands, spurs, and ligatures, with notches on the ribbed expansion arch to prevent slipping of the wire ligature, the movement being further assisted by the tightening of the nut on the expansion arch on the affected side.

The widened arch was retained by a vulcanite plate (Fig. 854). The mesial, torsional, and lingual tendencies of the right lateral and the lingual tendencies of the other incisors were resisted by bands upon the laterals connected by a piece of wire, G, soldered to their lingual surfaces. Fig. 881 shows the occlusion of the teeth eight years after treatment. The facial lines were practically faultless.

This type of malocclusion is more frequent among children than seems to be commonly supposed, and it is important that it receive early attention, for if allowed to progress the mouth must inevitably develop asymmetrically, the jaw shifting laterally, giving a peculiar twisted appearance to the mouth.

FIG. 881



Figs. 879 and 880 illustrate a case in its labial, buccal, and occlusal aspects, and from the position of the canines and that of the mesio-buccal cusps of the upper first molars it will be readily recognized as a typical case belonging to the first class.

It will be seen that the arches are much shortened and reduced from the normal size, with marked lingual positions of all the incisors, the left upper lateral being in contact with the first premolar, causing almost complete labial displacement of the left canine, while at least one-half of the space necessary for the right canine is occupied by the right lateral, the influence of the lips effectually maintaining the diminished size of the arches and the malocclusion.

The effect, as might be supposed, was very noticeable in the facial lines of the patient, as shown in Fig. 732, producing, as we have seen, a pinched and flattened appearance about the mouth.

What was clearly indicated was to place all the malposed teeth in harmony with the line of occlusion.

Fig. 882 shows the various necessary tooth movements being accomplished in both arches simultaneously by means of ribbed expansion arches,[1] D bands, spurred bands, wire ligatures, etc., adjusted and operated as described in the section on Adjustment and Operation of Appliances.

The anchorage was effected by means of D bands placed upon the first molars in the lower arch, while in the upper arch a D band upon the first molar was used on the right side and an X band on the first

Fig 882



premolar on the left side, it being found necessary after a few days of treatment to transfer the anchorage from the left first molar to this tooth, as the molar showed displacement distally in resisting the strain of the labial movement of the incisors. It is not surprising that the first molar did show weakness of anchorage and move distally in this case, as it may in all cases at this age, for the reason that the second molar gives it no support, it being still unerupted and lying in a large open crypt into which the first molar may quite readily be moved. It is usually well in such cases to reinforce the molar, which can easily be done by ligating it to the premolars.

[1] Several of the cuts showing the expansion arch were made before the invention of the ribbed expansion arch, therefore soldered spurs on the plain arch to prevent the slipping of the ligatures are shown instead of notches in the ribbed arch, as now used, but referred to in the text as though the notched ribbed arch had been used.

It will be noticed that there are two ligatures upon the left lateral incisor (upper). One is a plain ligature, as in *A*, Fig. 807, for effecting the labial movement; the second, as in *B*, Fig. 807, encircles the arch and a spur soldered low down upon the lingual surface of the band upon the lateral. The office of this ligature was partly to assist in carrying the incisor forward, but principally to effect its rotation. A notch in the rib of the expansion arch prevented this ligature from sliding forward and directed the movement of the tooth laterally, the arch being so bent that in shape and spring it bore toward the left and favored this movement, assisted reciprocally by the band, spur, and ligatures upon the right lateral. The reason for the spurs being placed well toward the gum, as is important in all such cases, is that it resists the tendency of the arch to slide toward the occlusal edges of the teeth. This tendency is further opposed by crossing the strands of the ligature near the spur during the adjustment of the ligature.

The right upper central is also encircled by a ligature, which is prevented from sliding off the tooth by the hand.

The form of the expansion arch was occasionally modified by bending to meet the requirements of the moving teeth and prevent bunching.

Owing to the lingual inclination of the crowns of the lower incisors no bands on them were necessary, the ligatures simply encircling the expansion arch and crowns of the teeth. It will be noted that a notch in the ribbed arch directed the movement of the canine laterally as well as labially.

The slight necessary rotation of the left second premolar was accomplished by bands, spurs, ligatures, and rubber wedges, as already described, as soon as the anterior teeth had been moved into correct position to reduce the crowding and permit it to turn. Fig. 882, made from a study model taken in wax with the appliances in position, shows the movements of the teeth nearing completion, where they were temporarily retained pending the eruption of the upper canines.

The teeth of the upper arch were permanently retained in their new positions by a section of wire G, soldered to the mesio-lingual angles of bands on the canines and made to bear against the lingual surfaces of the intervening incisors, as in Figs. 846 and 892.

The corrected positions of the lower canines and incisors were maintained also by a similar device.

The lesson we would especially impress in the treatment of this case of malocclusion is the important one of growth and development of the alveolar process subsequent to the movement of the teeth and the establishment of normal occlusion, for unless nature is induced to complete the growth of the bone which has so long been arrested, it will be impossible to maintain the teeth in their corrected positions, or to establish the proper contour of the face. In this case we were fortunate, for

after two years of retention it will be seen by comparing Fig. 883, which shows the upper model of the case soon after the completion of tooth movement, with Fig. 884, which shows the case nearly two years later, how pronounced and gratifying has been the growth and development of the intermaxillary bones in the region of the roots of the incisors, and the shifting of the very apices of the roots of these teeth as well.

FIG. 883

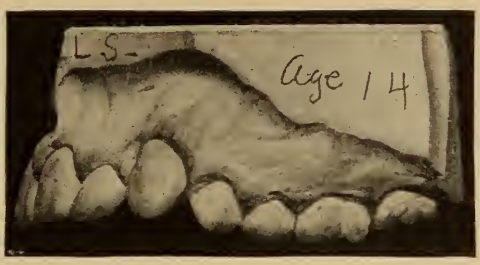


Fig. 733 represents the face of the patient at this time, and the improvement in the facial contour is also very noticeable and gratifying. Let the reader picture in his mind what would have been the result had extraction been resorted to in the treatment of this case—a practice

FIG. 884



still insisted upon by many. The function of occlusion would have been greatly impaired, the sizes of the arches diminished, and the tongue restricted, with the deformity pronouncedly manifest in the irreparably impaired facial lines.

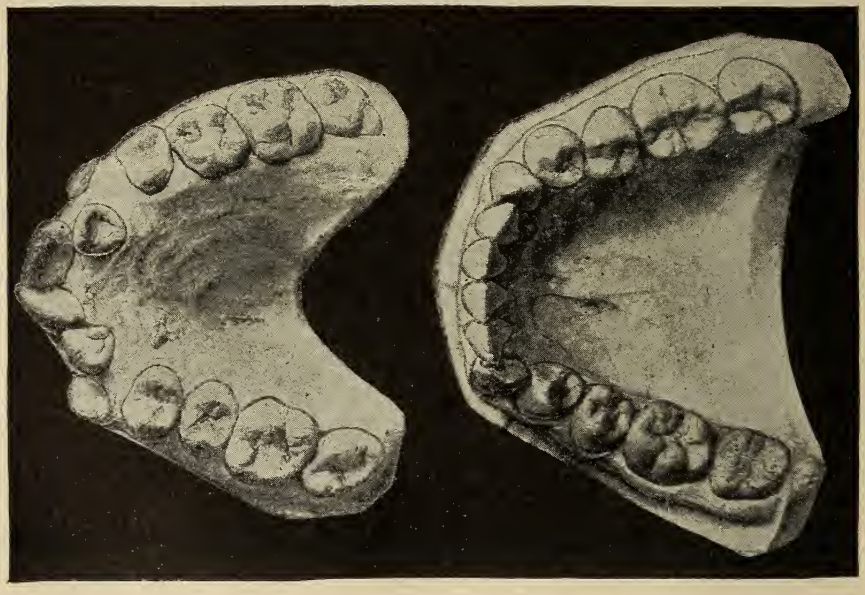
In the case represented in Figs. 885, 886, 887, and 888 the same

general plan of treatment and retention was followed as in the last case, and the very gratifying results in occlusion and bone development, and

Fig. 885



Fig. 886



the excellent harmony in balance of the facial lines of the patient three years later are shown in Figs. 889 and 890.

Had the working retainer been employed in both of the cases last shown, the same or possibly better results would have been accomplished, with a far shorter period of retention.

Fig. 887

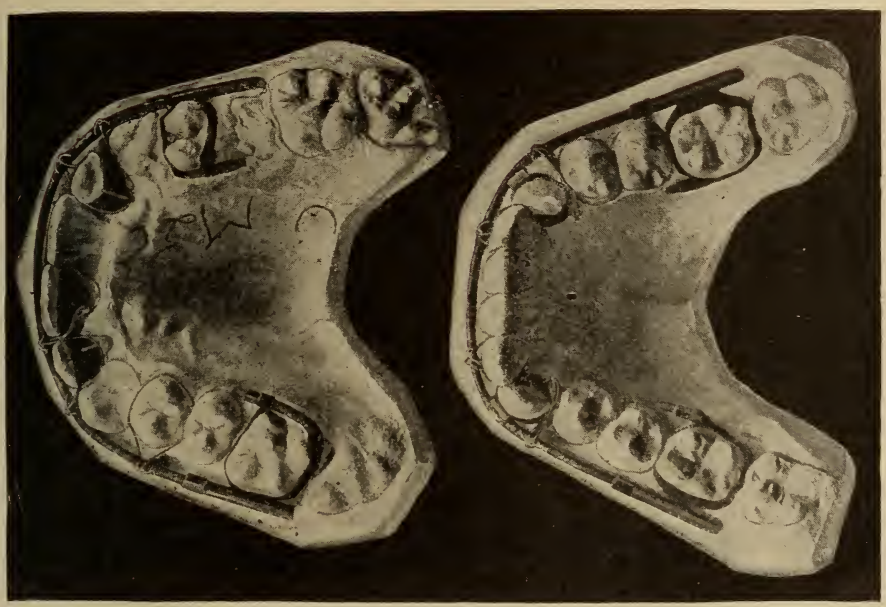


Fig. 888



Fig. 891 shows a case, also belonging to this class, in which there is much space between the occlusal edges of the incisors, the result of the habit of holding the tongue between the teeth. The cut also shows

Fig. 889

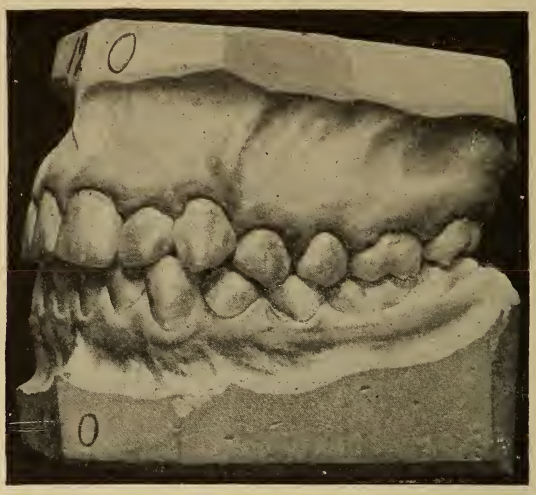
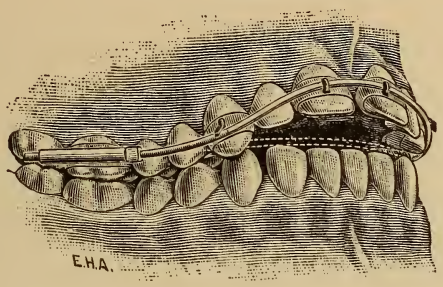


Fig. 890



the method of correcting the infra-occlusion of the incisors by means of the expansion arch. The middle of each side of the expansion arch was made to bear against a spur soldered to a band on the canine, which acted as a fulcrum, the centre of the arch being sprung over hook-like spurs projecting from the labial surfaces of bands on the incisors, and in its spring thus exerting a downward force upon them. Spurs, in connection with the bands on the incisors, for engaging the expansion arch, are now dispensed with, as better control of the amount of force to the moving teeth can be gained with a ligature as a medium of attachment, the bands being used only to prevent the ligature from slipping off the tooth. The ligature is placed about the neck of the tooth and given one twist, the arch sprung up and engaged with the ligature, which is then given another twist.

Fig. 891



In many instances the bands may also be dispensed with by placing a ligature about the neck of the tooth above the gingival ridge, twisting it in the usual way, then cutting the ends off short. The ligature is then conformed still more closely to the size of the neck of the tooth by giving it a final set or part of a twist with the How pliers. Another or independent ligature is then passed between the neck of the tooth and the first ligature and made to engage the latter and the expansion arch, for giving the downward tension upon the tooth. Either of the arches *E* or the arch *B* may be used.

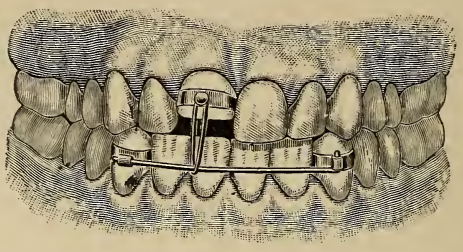
In correcting infra-occlusion of the teeth by this excellent method, it has been found that the spurs acting as fulcrums are unnecessary, the spring of the arch gained through the pry of the sheaths of the anchor-bands usually being ample. It is well, however, to reinforce this anchorage with intermaxillary anchorage; that is, stretching delicate rubber ligatures from hooks attached to the upper expansion arch to others upon the lower expansion arch, or to attachments on the lower canines, as in Fig. 892.

The best means of retaining teeth so elevated is to allow the expansion arch to remain in position the requisite time.

Fig. 893 shows another case of pronounced infra-occlusion of the

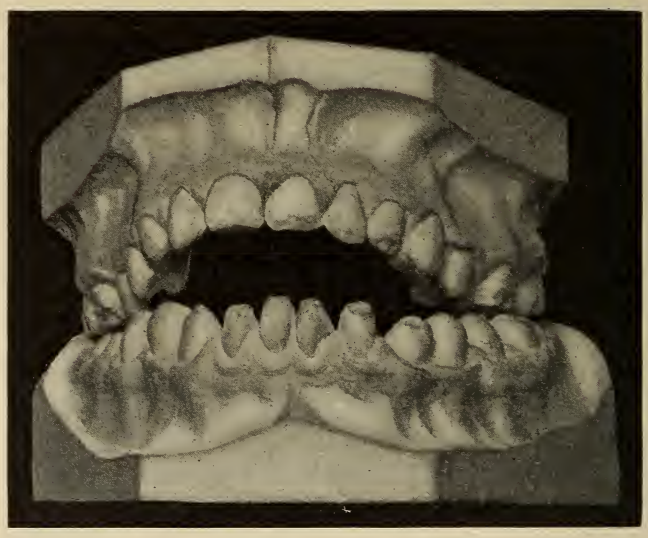
incisors, canines, and premolars, principally of the upper arch. This condition was augmented by the slight supra-occlusion of the second molars, they being the only teeth that came in contact when the jaws were closed.

Fig. 892



The plan of treatment which seemed most advisable was the shortening of the second molars and the lengthening of all the incisors and canines. This was accomplished by means of the spring of the expansion arches reinforced by intermaxillary anchorage, exactly as described in the last case.

Fig. 893



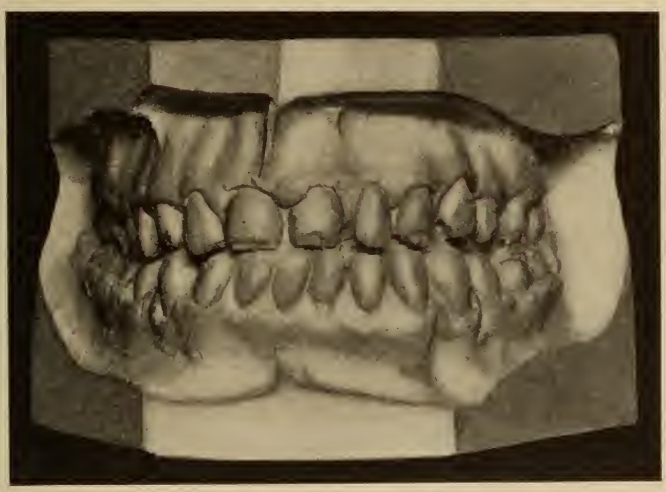
All of the lower incisors and canines and the upper lateral incisors and canines were banded with delicate neatly fitting bands made from the thinnest band material (C). These bands were to prevent the ligatures from slipping off the teeth. This was necessary, as the shapes of these teeth were not favorable for retaining the ligatures twisted above their gingival ridges, as suggested in connection with the case last described, but the shapes of the upper centrals being favorable, no bands were needed on them. The finest of the three sizes of wire ligatures were used in ligating the teeth to the expansion arches, after

the latter had been bent to give the greatest downward spring to the upper and upward spring to the lower. The force from this spring was intensified by two of the delicate rubber ligatures, which were stretched from one arch to the other and made to engage spurs which had been soft-soldered to the expansion arches opposite the canine teeth.

It will be noted that the left lower first molar is in buccal occlusion, and that its antagonist is in lingual occlusion. The expansion arches, before insertion, were bent to give spring for the correction of these positions.

After the movement of the teeth had been continued for about six months a period of rest was given the patient to await the growth of the alveolar process, during which time retention of the teeth was effected simply by allowing the arch and ligatures to remain passively

FIG. 894



in position. The case was of course occasionally inspected to make sure that all bands and ligatures were in order, and at the end of the period of rest the development of the tissues was noticeable and gratifying. The expansion arches were removed and, after bending them to give the necessary spring, they were reinserted and tension again given to the teeth through the adjustment of ligatures, as previously. After continuing the movement very slowly for three months more, an impression was taken of the labial and buccal surfaces of the teeth while in occlusion, as illustrated in Fig. 894, which truthfully indicates the relations of the teeth at this time.

Further movement of the teeth seemed unnecessary. The patient was again dismissed with instructions to return for occasional inspection of her teeth, which were retained as formerly by means of the arch

and ligatures. These were worn for about a year and then removed. No unfavorable movements of the teeth recurred.

Great caution should be observed in all such extensive operations for elevating the teeth not to excite inflammation or to move the teeth too rapidly. The movement should be very slow, but continuous, otherwise there will be great danger of destroying the pulps. This should be apparent when we remember how extensive must be the changes in the peridental membrane and alveolar process, and what a severe strain is put upon these tissues incident to effecting such great changes in the positions of the teeth.

Such cases present many points of interest, especially the readiness and completeness with which the gum tissues, and probably to some extent the alveolar tissues, follow the teeth in these extensive move-

Fig. 895



ments. It is doubtful whether the treatment of these cases should ever be undertaken after maturity, although we have as yet nothing but theory to suggest fear of alveolar disintegration as a result later in life. Another is that a surprisingly large percentage of cases of this type show the effect of some serious systemic disturbance early in the development of the enamel of the incisors and first molars, strongly suggesting the closer study of the early history of these cases if we would learn their cause.

That this case might have been treated more satisfactorily from beginning to end by means of the working retainer device shown in Figs. 858 and 859.

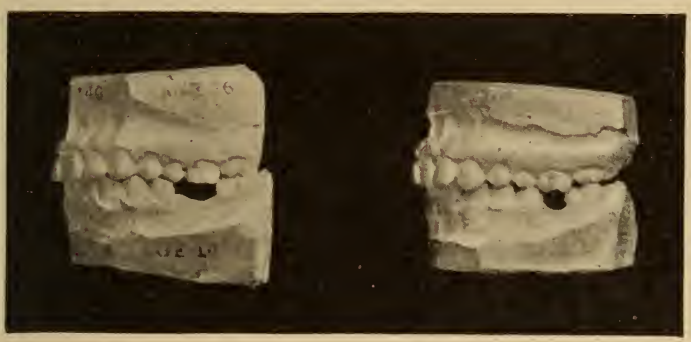
Fig. 895 shows the buccal aspect of a case of malocclusion before and after treatment, the cause of the malocclusion being mutilation by

extraction. The occlusion on the right side was normal. On the left (upper model) the lateral halves of both arches were shortened, the upper permanent lateral incisor being in contact with the first premolar. There was a shrunken appearance of the mouth, and the incisors were shifted from the median line. This condition was the result of the unfortunate and unnecessary loss of the deciduous upper canine and the first and second deciduous lower molars.

It needs but slight reflection to realize what must follow as the result of this loss. The permanent upper canine on erupting must be forced into pronounced labial occlusion, with marked disturbance of the left lateral and central, while in the lower jaw marked malocclusion must follow the eruption of the premolars.

The treatment clearly indicated was the lengthening of the left lateral halves of both arches the full amount of the missing teeth by carrying forward and laterally (to the right) all the incisors.

Fig. 896



This was accomplished in both arches simultaneously by means of expansion arches, bands, and ligatures. No bands on the teeth to be moved were necessary. The incisors were laced to the arch with plain ligatures, as in *A*, Fig. 807. The notches in the ribbed arches for preventing the ligatures on the upper lateral incisor and lower canine from slipping were placed about opposite the middle of the centrals, so that force produced by tightening the nuts in front of the anchor sheaths on the first molars exerted a direct mesio-labial movement of these teeth, and as the nuts were tightened only on the affected side the lateral shifting of the incisors, as the arches were lengthened, was natural and easy.

The result of treatment is shown in the lower model, the sides of the arches having been sufficiently lengthened to admit of the eruption of the upper canine and lower premolars.

Retention of the space for the premolars in the lower arch was effected by means of the device shown in Fig. 837, and for the upper canine as shown in Fig. 838. These were worn until the eruption of the teeth

made their use no longer necessary. This is a very desirable method of retention in all similar cases.

On the right of the engraving (Fig. 896) is shown the model of a case from which several valuable lessons may be learned. The case was that of a girl, aged sixteen years. Two years previous to the making of this model the occlusion of her teeth was practically faultless, and, with the exception of the left lower first molar her teeth were of excellent structure and color. At this time this molar was lost through extraction. Then progressively followed the perversion of the normal forces:

1. The tipping forward of the second molar—the inevitable result.
2. The shifting distally of this lateral half of the mandible.
3. Pressure from the lower lips, which, in connection with the shifting distally of the mandible, would soon move into complete distal occlusion the teeth in this lateral half of the lower jaw anterior to the space.
4. Pressure from the upper lip has gradually moulded the upper arch to conform to the diminishing size of the lower, as shown by the bunching of the upper incisors.

In connection with this case attention was called for the first time in literature to the shifting distally of the mandible as one of the results of extraction of the first permanent molar.[1] It should be explained that this *must* result as the fixed relations of the crown through the inclined occlusal planes with those of the opposing teeth, so that in reality, instead of the crown of the lower second molar tipping forward, as it appears to do, the mandible and the apices of the root of this tooth move distally, following the line of least resistance. Later the restraining influence of the occlusion would be wholly lost. Then the actual tipping forward of the crown of the tooth will occur, as in Fig. 897.

The treatment clearly indicated was the lengthening of the lateral half of the lower arch, the tipping to an upright position of the second molar, and the correction of the positions of the teeth in the upper arch, or the restoration of the occlusal planes of all of the teeth to their original positions, as is shown in the model of the completed case on the left of the engraving Fig. 896.

The patient was then referred to her dentist for an artificial substitute for the lost molar, which, being provided in the form of a bridge, served the double purpose of retention and mastication. The requirements of orthodontia and bridging are such as should induce a closer study of their relations, and if, before making bridges for their patients, dentists would refer them to competent orthodontists, better results would very often follow. The placing of bridges on leaning piers is unmechanical, and, as applied to the mouth, is also unphysiological.

A point we would emphasize in relation to this case is that the changes

[1] Angle, Malocclusion of the Teeth, sixth edition.

taking place in this previously faultless arch, as the result of the loss of the first molar, are such as must and do always follow the loss of this tooth. Examine a thousand similar cases, and as many similar results will be found.

It will be noticed that in the model on the right none of the teeth on the left side occlude, but that they merely touch at irregular intervals, and are practically worthless for mastication. What we would especially emphasize in this connection is that the lost tooth must be immediately replaced by some form of artificial substitute, or the serious impairment of the occlusion of the remaining teeth on the side of the arch from which the tooth has been extracted will certainly follow.

FIG. 897



As the same plan of treatment was employed for accomplishing the various necessary tooth movements in this case as in overcoming the same, but more complicated, problems in the case next to be shown, they will be described in connection with that case.

Figs. 897 and 898 show a most unfortunate result from both right and left sides, following the extraction of the four first permanent molars, which, though perfectly sound, were removed at the age of nine years, with the idea of making space to prevent malocclusion of the other teeth, and how successful was the effort is readily seen. The result is but natural. Not only have the remaining teeth been rendered almost useless for mastication, but in recent years there has been chronic pericementitis, resulting from the wrongly directed force upon the molars in their tipped and abnormal positions. The facial lines were also greatly marred by the arrest in the development of the alveolar process, as shown on the left in Fig. 741, for without the wedging influence of those most important

teeth—the first molars—the teeth anterior could not be pushed forward by the eruption of the second and third molars, which is necessary for the proper contouring of the face.

Gold capping of the leaning molars, resorted to by the patient's dentist in this case to improve the occlusion, only aggravated the condition, for the gold crowns only gave a longer leverage, thereby increasing the force through occlusion for the further tipping of the teeth.

There was but one logical and rational plan of treatment, namely, to regain the lost spaces of the four molars by carrying all the teeth anterior to them forward, and those posterior to them somewhat distally and to an upright position, and replace the missing teeth by artificial substitutes.

FIG. 898



To accomplish this all four second molars were carefully fitted with D bands, the sheaths on the lower bands being resoldered to align properly with the expansion arch. The ribbed expansion arches were then carefully bent to conform to the outside of the dental arches, and were inserted without lateral spring in the sheaths of the clamp bands, as widening the dental arches was not necessary.

The central and lateral incisors of the upper arch were then ligated to the upper expansion arch, the simple ligatures, as in *A*, Fig. 807, being employed, and in like manner were the lower incisors attached to the lower expansion arch.

Hook-like notches were then filed in the ribs of the expansion arches directly opposite the space between the lateral incisors and canines. Next strands of the heaviest ligature wire were looped over the distal surfaces of the second premolars, the ends brought forward, and the end of each lingual strand passed through between the canines and lateral

incisors, and the two ends of each strand made to engage their notch in the rib of the expansion arch, just described, firmly drawn, and given three-fourths of a twist, the surplus wire cut off, and the ends bent out of the way, as usual, thereby at once exerting tension in a mesial direction on all the second premolars, which, in turn, was transferred to the first premolars and canines, with a labial movement of the centrals and laterals. This force was, of course, transmitted in the opposite direction to the second molars, and, in turn, to the third molars. The nuts of the expansion arches were tightened by giving them one revolution twice a week. The result was the gradual carrying forward of all the teeth anterior to the spaces, and at the same time the movement of all the molars distally.

The most difficult problem apprehended was to gradually effect at the same time the tipping to an upright position of the greatly leaning lower second molars. Yet this was easily accomplished by bending each end of the lower expansion arch downward, slightly, at a point just anterior to the nuts on the same, so that when the arch was inserted in the sheaths of the anchor bands and the anterior part of the arch was drawn up and ligated to the incisors, there was a pry upward on the mesial ends and downward on the distal ends of the sheaths of the lower anchor bands, which being transmitted through the tightly clamped bands to the teeth, the effect was to rapidly tip the molars upward and backward.

As the movements progressed, the spring of the arch from the upward pry gradually became insufficient, necessitating the removal of the lower D bands and the resoldering of their sheaths in order to again intensify the force and cause the further tipping distally of the molars.

As it was desired to carry all of the teeth anterior to the spaces well forward, the force necessary was so great that before the movement of these teeth was completed the molars had been carried to an upright position and as far distally as was necessary. Their further movement was then arrested by so bending the ends of the arches as to occasion their binding in the sheaths and prevent further tipping distally of the molars, or changing the anchorage from simple to stationary.

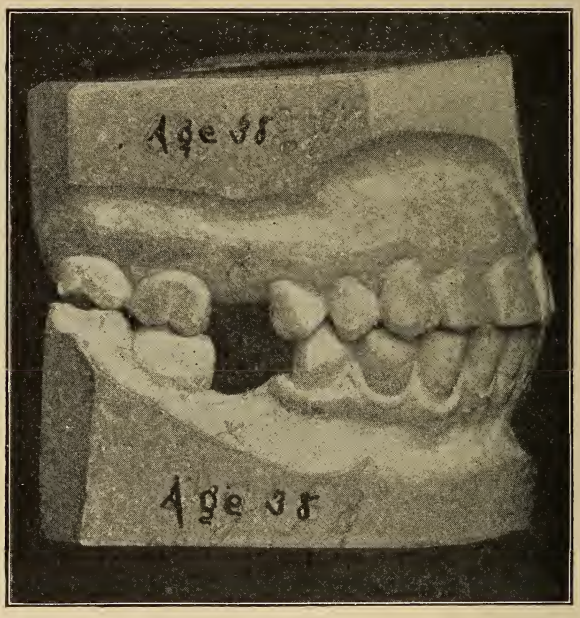
The retention in this case now would be to allow the regulating appliances to remain passively upon the teeth a short time, replacing them later by the lingual arch retainer, shown in Fig. 857, and finally removing it and replacing the missing molars by proper bridges.

Notwithstanding the advanced age of the patient (thirty-eight years), supposedly unfavorable for the treatment of malocclusion, it being the most advanced age recorded for such an extensive operation, the writer was agreeably surprised to find that the teeth were moved quite as easily and fully as rapidly as is usual in the case of a miss of eighteen, and with no unfavorable symptoms following the movement of any of the teeth.

The result in occlusion is shown in Fig. 899. It will be seen that all of the teeth anterior to the space have been carried well forward and that the molars have been moved distally and into correct relations.

The remarkable changes in the sizes of the arches and in the relations and inclinations of the teeth are naturally reflected in the lines of the mouth as related to the other features, as will be noted by comparing the face after treatment (on the right in Fig. 741) with its condition before treatment (on the left in Fig. 741). Yet great as are the changes in the facial lines, the close student will observe that there is still not complete normal contour of the mouth, which, as we perceive, is but natural when we remember how the arches were robbed in youth of that normal wedging influence of the first molars, so necessary to effect the normal development of the bones of the face and its consequent normal contour, which could not be wholly regained so late in life.

Fig. 899



Another point of great interest in connection with this case is the positive proof that even in this remarkable case the second upper molars had not moved forward farther than their normal positions, notwithstanding the early loss of the first molars.

Other cases belonging to this class, almost innumerable, might be cited, but as their variations from the cases already shown would be principally in degree, with the same general plan of treatment, it is unnecessary to do so.

Treatment of Cases, Class II, Division 1.—It will be remembered that the distinguishing characteristics of cases belonging to this

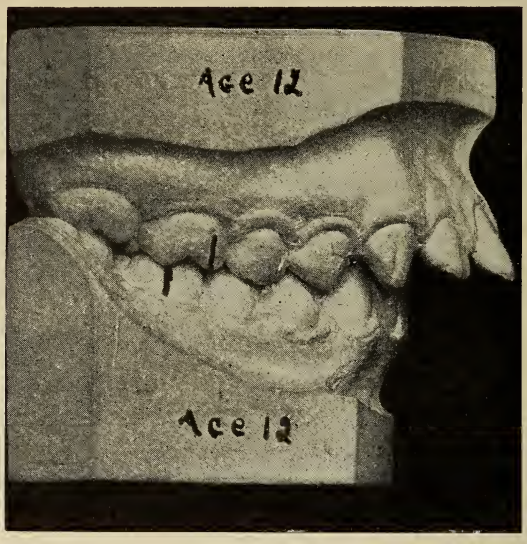
division of this class are distal occlusion of the teeth of both lateral halves of the lower arch, with more or less deformed and underdeveloped mandible, narrowed upper arch, and protruding upper incisors. It will also be remembered that those afflicted with this type of malocclusion are in almost every instance affected with some form of nasal obstruction necessitating mouth breathing, which usually begins at an early age, causing the mouth to be held open almost constantly and the lips and buccal muscles to act abnormally. In the effort to breathe, the upper lip is drawn upward and fails to develop in size and function, exercising little restraint upon the labial movement of the incisors. Their protrusion, therefore, becomes more and more pronounced, partially as a result of pressure from the tongue and narrowing of the arch through malocclusion and the action of the buccal muscles, but principally because the lower lip is so frequently forced against their lingual surfaces in swallowing and in the effort to moisten the mucous membrane of the mouth. The lower incisors become lengthened, probably from lack of function, so that their occlusal edges are in many cases in contact with the mucous membrane of the hard palate.

It is commonly supposed that this form of malocclusion is the result of overdevelopment of the upper jaw. The writer has never seen a case where this condition existed, neither are the teeth of the upper jaw "inherited too far forward," as is pointed out in the chapter on Occlusion.

The narrowed upper arch and protruding upper incisors, the lower jaw abnormal in form and distal in relation, the arrest in the development of the nasal apparatus, the modification in form and function of the nose and muscles, and the marred facial lines are but the natural results of the failure of the first permanent lower molars to lock normally at the time of their eruption, accompanied and probably preceded by pathological conditions of the nose or throat that established the habit of mouth breathing. It is interesting to note the gradual and progressive development of cases belonging to this class—the result of perverted forces in this combination. It seems reasonable to believe that the mandible is prevented from developing normally through the distal locking of the teeth and the consequent abnormal distribution of force from the muscles and the force of occlusion. Normally the force is distributed on the line of the long axes of the teeth, but when the lower molars lock in distal occlusion the force is received principally upon the anterior half of their crowns, as shown in Fig. 900, the tendency being to drive their apices distally, or at least to prevent their normal movement forward, which would also prevent the normal growth and lengthening of the mandible. This seems hitherto to have been unnoted, yet it seems most probable when we consider how pronounced is the interference with the normal growth of the mandible, maxilla, and alveolar process, by the abnormal distribution of force in those cases where the upper teeth on erupting lock in lingual occlusion.

Cases belonging to this division usually begin with the mal-locking of the first permanent molars at the time of their eruption, although we now know that they may be established much earlier, or during the development of the deciduous denture, and this is not remarkable, since nasal obstructions from adenoid growths and other causes are often well defined at two and three years of age. This may be so slight at first as to occasion mouth breathing only at intervals and later disappear entirely, but if sufficient at the time of the eruption and locking of the deciduous teeth, or of the first permanent molars, to decide the distal locking of the cusps of the teeth—and but a few days would be necessary to accomplish this—the nucleus of conditions would be established which must progress until all of the conditions of a typical case of either the first or second divisions of this class have developed. Or, if the distal locking should occur only on one side, the case would belong to the subdivision of either the first or second division.

Fig. 900



Once established, it is remarkable what similarity exists between the cases of each division, especially those of the first, the differences being chiefly in degree, which is usually in proportion to the age of the patient. And, as we have already noted in the section on Facial Art, the disturbance in the balance of the facial lines is very characteristic and in direct proportion to the degree of the malocclusion.

That we may the more intelligently decide as to the proper plan of treatment in these cases, there is another question which is well worthy of consideration, and it is the inharmony in the relations of the opposing planes of the teeth in their distal occlusion. Apparently this is not great, judging from a superficial examination of the buccal relations when the

jaws are closed, as is well illustrated in Fig. 900, or any similar case, but in reality it is very great, for it must be remembered that each occlusal plane has a special form designed by nature to beautifully match and harmonize with its natural opposing plane, to be most efficient in occlusion and function, as we have seen in studying the normal. But with the teeth in distal occlusion, each inclined plane is opposed by one inharmonious in form and relation, with far less inefficiency in occlusion and function. This is better shown by a study of the lingual aspect of this same case shown in Fig. 901. It would be hard to estimate how greatly the efficiency of the molars is thus impaired.

Fig. 901



The writer is more and more impressed with the belief that this lessened efficiency and perversion of the occlusal forces has much to do with the maldevelopment of the mandible in these cases.

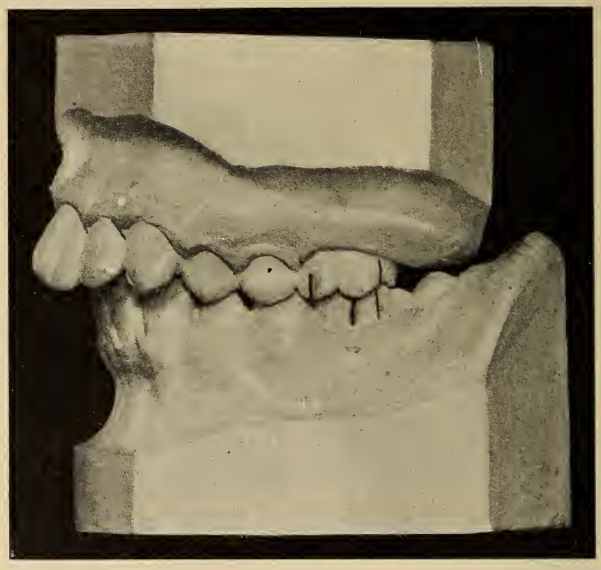
The modern, logical plan of treatment of cases belonging to this division is to divert from abnormal to normal action the forces which are operative in producing the deformity, or, first to remove the cause by proper treatment of the nose, making normal breathing not only possible but actual, and then to establish the proper relations of the occlusal planes of the teeth—normal occlusion—beginning with the correction of the malpositions of the first molars, and following in the order of the teeth mesially, ending with the incisors, instead of beginning with the protruding upper incisors, the symptoms, as it were, as in the old plan of treatment of which we shall speak later. Then retaining the teeth until all of the tissues and muscles involved shall have become normal in growth

and harmonious in function through their mutual coöperation. Naturally the earlier the treatment, the more perfect must be the ultimate result.

Fig. 902



Fig. 903



This plan of treatment is illustrated in the following typical average case—that of a girl, aged thirteen years. The case is shown from the buccal aspect of the right and left sides in Figs. 902 and 903. The

molars, premolars, and canines in both lateral halves of the lower jaw have erupted and locked in distal occlusion, with consequent inharmony in the sizes of the arches and a corresponding inharmony as to the size of the mandible, also resulting in exactly proportionate disturbance of the beauty and balance of the facial lines, as shown by the profile in Fig. 904.

To establish normal occlusion it was necessary to tip the crowns of all the lower teeth forward and those of the upper arch distally, sufficient to establish the normal mesio-distal relations of the inclined occlusal planes. The degree to which the teeth of each arch shall be moved varies in different cases. Usually the movement should be about equal in each arch, for reasons to be noted later.

Fig. 904



The anchor bands D were carefully fitted to all four first molars, putting the bands well over the crowns, with the tubes aligned correctly, and the screws of the clamp bands lying close to the lingual surfaces of the adjoining teeth, and the bands finally clamped and burnished to complete adaptation. Plain expansion arches were now carefully shaped to conform approximately to the sizes of the dental arches and slipped into place, the upper expansion arch aligning a little below the gingival margin of the incisors, and the lower expansion arch aligned about the middle of the labial surfaces of the lower incisors. Points opposite the upper lateral incisors were now indicated on the upper expansion arch, the arch removed, and a sheath-hook attached at each of the two points indicated by means of a very small piece of soft solder, the arch carried to a very delicate flame and the temperature

slowly raised to the fusing point of the solder, jeweller's soft soldering fluid being used as a flux. When gold instead of nickel silver is used for the arches this form of sheath-hook is not used, but hooks, also of gold, are soldered directly to the arch with 22 k gold solder. Soft solder must not be used on gold nor hard solder on nickel silver arches.

The sheath hooks being attached to the arch, it is again inserted in the tubes of the clamp bands, with the friction sleeves of the nuts carefully adjusted in the extension flange of the anchor tubes. Much care must be exercised in adjusting the bands and the arches so that the beautiful fit of the extension flange of the nut with the friction sleeve of the tube of the clamp band will not be injured.

As lateral force on the upper molars was not required in this case, they being in their proper lateral as well as mesio-distal positions, little or no outward spring was given to the expansion arches. Great care was exercised to bend the upper expansion arch so that it would lie close to the teeth, yet not touch any of them, and in this way avoid interference with the upper lip and inconvenience to the patient, as well as making the appliance less unsightly.

All having been properly adjusted, one of the delicate rubber ligatures was caught over the distal end of the sheath of the anchor tubes on the lower molars on each side, stretched forward and engaged with the sheath-hooks on the upper expansion arch, as shown in Fig. 806, at once exerting gentle but constant force distally on the upper molars and mesially on the lower molars, premolars, and canines.

The appliance was now carefully inspected, to be certain that no sharp corners should abrade the tissues, and especially that the threaded ends of the arches did not protrude distally through the tubes, these ends having been cut off and polished when the arches were fitted. Any exposed portion of the threads, either on the clamp bands or expansion arches, were carefully gone over with a burnisher. The patient was directed to keep the mouth closed as much of the time as possible, that the force exerted by the rubber ligatures should come at the most favorable angle for accomplishing the movement. The patient was then given a half dozen of the rubber ligatures and instructed as to how to apply them, in case of accident to those already in position, and was then dismissed for one week.

In order that the patient might be caused as little pain and inconvenience as possible, both in the fitting and adjusting of the appliances and in becoming accustomed to wearing them, a number of short sittings, extending over a period of at least two weeks, were employed, never putting on more than one band or one arch at a time, or more than one rubber ligature on a side, and that of the most delicate tension. Later two, or even three, ligatures may be worn on each side with little or no inconvenience. Thus by avoiding pain and minimizing the inconvenience to the patient in the beginning, success in treatment is made more certain.

At the end of a week the patient returned, and it was found that the lower teeth had tipped slightly forward, as evinced by the anterior part of the expansion arch having moved perceptibly downward toward the gingiva. The upper molars had also moved slightly distally, as evinced by the expansion arch resting in contact with the labial surface of the incisors, as well as moving downward toward their cutting edges to a noticeable degree on account of the upper molars having tipped distally. The nuts in front of the anchor tubes on the upper molars were now tightened by giving them one and one-half revolutions. Both expansion arches were then removed and the upper one given a very slight upward bend just anterior to the nuts, so that it would align correctly. The arch must never be bent but very slightly. It is better to secure alignment by readjusting the anchor bands, or even by changing the angle of the anchor tubes by resoldering, although the latter is rarely necessary.

The teeth and arches were then thoroughly cleansed, the latter slipped back into place, fresh rubber ligatures adjusted, and the patient instructed and encouraged in the proper cleansing of the teeth and dismissed for another week, when the nuts on the upper expansion arch were again tightened to avoid any pressure on the anterior teeth and to continue to concentrate it all on the molars.

This treatment was continued until the upper and lower molars were in complete normal mesio-distal relations. Indeed, the movement was continued until the molars were carried a little beyond their normal relations, to allow for the unavoidable slight recurrent movement of these teeth during retention.

The upper arch and anchor bands were then removed and the teeth thoroughly cleansed. X bands were adjusted to the second premolars, the nuts turned well forward on the expansion arch, the tubes aligned properly, and the same expansion arch again inserted, with the nuts again so adjusted with the tubes on the X bands as to prevent any pressure on the anterior teeth. Then force from the intermaxillary rubber ligatures was again applied. To insure the distal movement of the first premolars at the same time, they were ligated to the second premolars. In about two weeks the first and second upper premolars on both sides had been moved sufficiently distally. The canines had also been moved somewhat distally through their relations with the tissues of the alveolar process and peridental membrane.

The nuts on the upper expansion arch were then turned well back, to release the force distally on the molars and premolars, and to allow all the force now to be received by the upper incisors and canines. About three weeks was required to accomplish their necessary distal movement.

As the same amount of force had been received on the lower as on the upper teeth, the extent of the movement of each was about the same, and all were now in normal occlusion.

There was found to be some slight malalignment of the lower incisors at this time, which was corrected by means of the expansion arch

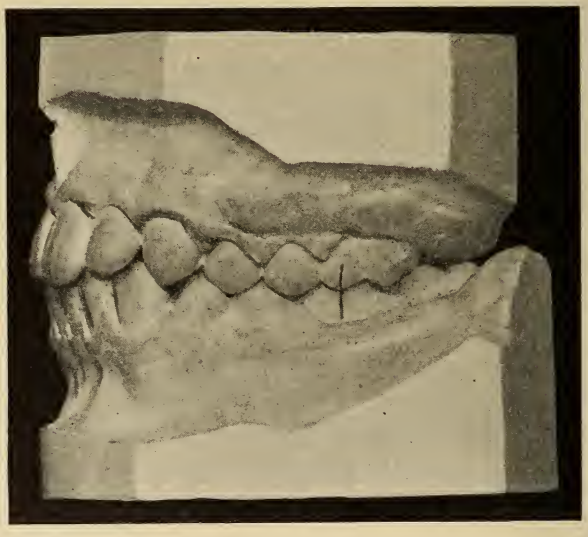
FIG. 905



already in position, plain spurred bands, and wire ligatures, the same as if the case had belonged to Class I.

The teeth were retained temporarily in their new relations by the appliances already in position, using only the most delicate force from a single rubber ligature on each side and stretching this only one-half

FIG. 906



the distance from the tube to the hook, the remaining distance being pieced out by a strand of floss silk.

After about three weeks of temporary retention the appliances were all removed, the teeth again thoroughly cleansed, impressions taken, and models of the teeth made, which are shown in Figs. 905 and 906.

The retention of the molars was effected by adjusting a No. 2 clamp band to each of the molars, the bands fitted with planes and spurs as described for the retention of Class II cases in the section on Retention.

The upper incisors were retained by means of the lingual arch shown in Fig. 857, its ends being soldered to the ends of the screws of the clamp bands, and the incisors held in proper relation with the arch by brass wire ligatures, as described in the section on Retention for cases belonging to this class.

Fig. 907



The lower incisors were retained by plain bands of precious metal on the canines, connected lingually by a section of wire, G, as in Fig. 846.

A second profile photograph of the patient was now taken, shown in Fig. 907, and although there is much improvement in the facial lines, complete normal contour of the face is still lacking, as is easily understood when it is remembered that we have corrected the occlusion of the teeth only. There still remains the underdeveloped and malformed mandible. And again, the muscles had been abnormal in development and function, and many months must elapse before they will become harmonious with the teeth in their new relations. Indeed, the relations of the muscles cannot be entirely normal until the mandible has undergone much modification in growth and development. But as the forces through occlusion have been changed from the abnormal to the normal, as well as those of the muscles of tongue and lips, the normal in the growth has been made possible, and nature is stimulated to complete

the dental apparatus normally, or in accordance with her original design of the type of this child. And that nature will do so in these cases and has done so in this case is shown by the picture of the patient three years later, in Fig. 908, and it is plain to be seen that the mandible has developed to normal proportions, with correspondingly gratifying results in the balance of the face.

This case also has an historical interest, for it is the first case of the kind where the history was carefully followed and reported in proof of the subsequent development of the mandible.

Fig. 908



In establishing the normal mesio-distal relations of the teeth in this case, and in all similar cases, the question which would naturally be asked is, Why was it necessary to move the molars and premolars of the upper arch distally if they were already, especially the first upper molars, in their normal mesio-distal positions and relations with the skull? The answer is very simple, namely, that we might the more easily and quickly and safely establish the normal in relation of the inclined occlusal planes of the teeth, and the better stimulate the normal in the growth of bone. Another reason is that if all of the movement had been confined to the lower teeth, they would have been tipped to an unsafe angle of inclination, but by striking a balance between the teeth of the two arches this is avoided.

Of course, in proportion as the upper teeth are moved distally to the true line of occlusion, the effect is to disturb the balance of the face so far as the upper dental arch is concerned, and this is often seen in these cases after following this plan of treatment; but it must be remembered that the movement of the upper teeth distally and the consequent disturbance of balance of the facial lines is but temporary. The changes in development subsequent to tooth movement must and do gradually carry the upper teeth forward again, and thus through the influence of the inclined planes constantly stimulated to greater activity and better final development of the mandible, for it cannot be too often repeated that intelligent efforts in orthodontia can never be more than to assist nature in the normal building of the denture according to the type.

Fig. 909



In the treatment of these cases, if there is pronounced arrest in the development of the mandible, it may be found that the lower teeth already incline forward to such an extent that to tip them still farther forward, equal to one-half of their distal relations with the upper teeth, as was done in the treatment of the case last described, would result in placing them at such an unsafe angle of inclination as to possibly interfere with the subsequent development of the alveolar process. Such a case is shown in Fig. 909. It is then advisable that the movement shall be greatest in the upper teeth, and to prevent the lower teeth from moving too far forward they must be arrested in this movement at the proper time. This is easily accomplished by enlisting stationary anchorage between the lower teeth and the lower expansion arch by so placing the clamp-bands on the lower molars that the tubes will cause the expansion arch to line well down below the gingiva in front, then by springing it up and lacing it to the lower incisors by means of wire ligatures, an upward and backward pry will be given to the molars by the elasticity of the arch, which will prevent further tipping and mesial movement of

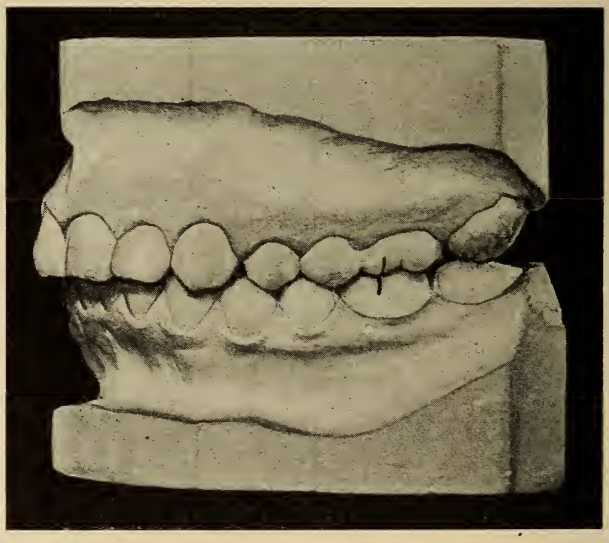
the lower teeth, and all of the movement will be given to the upper teeth. In like manner the movement of the upper teeth may be arrested when this is desired.

Fig. 910



Fig. 910 shows the upper arch of this case at the completion of the distal movement of the molars and premolars, or at the time the force was released from the molars, by turning the nuts forward and transferred to the upper incisors. It is in such cases as this that auxiliary

Fig. 911



force from occipital anchorage by means of the headgear and traction bar may with advantage be used to assist the intermaxillary ligatures in carrying the upper teeth distally, yet this necessity would be very rare, provided the movements of the teeth and the intermaxillary anchorage

were carefully watched and intelligently managed. The completed case is shown in Figs. 911 and 912.

Figs. 913 and 914 show the occlusion of the teeth in a well-defined case belonging to this division of a child, aged less than four years.

Fig. 912



It will be seen that all the lower teeth are in distal occlusion and all of the forces wrongly directed, and that the malocclusion must be continuously progressive so long as these conditions are permitted to exist.

Notwithstanding the complexity of the malocclusion and the extreme youth of the patient the treatment was easily and successfully performed

Fig. 913



by the plan described for the treatment of the case shown in Figs. 902 and 903, and Figs. 915 and 916 show the splendid results in the establishment of normal occlusion.

By comparing Fig. 917 with Fig. 918 it will also be noted how marvel-

Fig. 914



Fig. 915

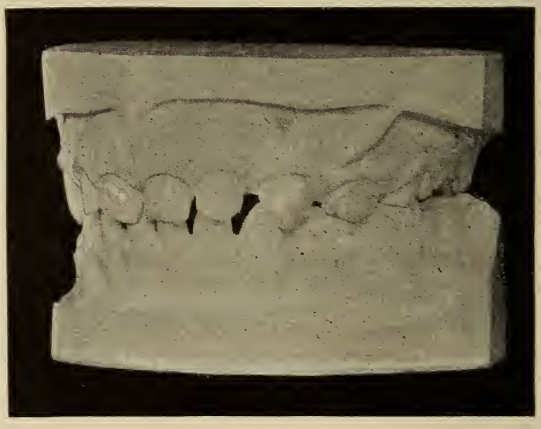


Fig. 916

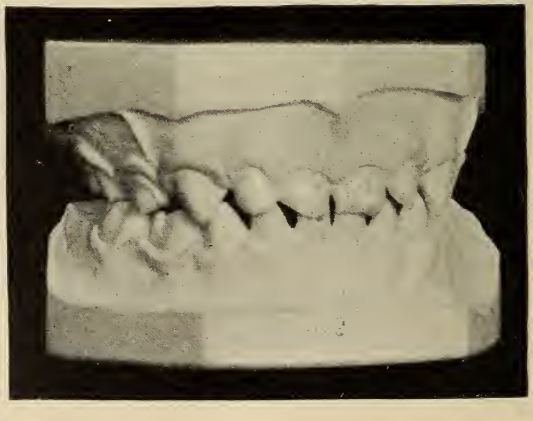


Fig. 917



Fig. 918



lous are the changes in the facial lines of this child as a result of this treatment.[1]

As the result of intelligent treatment, nature is now permitted to progress normally in her work of building the denture, and normally erupting and locking the first permanent molars, and the prospects of the ideally normal result, as compared with the possible result in cases that have been allowed to progress until "all of the teeth (permanent) have erupted," ought strongly to impress all thoughtful persons with the gravity of the error of delay.

Formerly two other methods were employed in the treatment of cases belonging to this division of this class. The one almost universally followed was to extract the first upper premolars and carry the incisors and canines distally by means of occipital force to close the spaces. By this method the patching up of one deformity by creating another often left the malocclusion worse than at the beginning of treatment, often added to the deformity of the face, and made further improvement and development hopelessly impossible. The method is so crude, illogical, and unscientific from every standpoint that it has been completely abandoned by all true orthodontists.

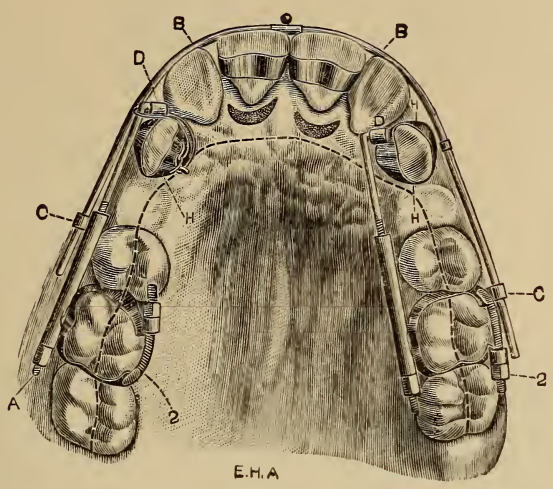
The other plan formerly employed was far more ideal. It was given us by that talented man, Dr. Norman W. Kingsley, and was known as "jumping the bite." It consisted in the patient's moving the mandible forward voluntarily until the teeth were in normal mesio-distal relations, the width and form of the upper dental arch having been so modified by previous corrective measures as to make this possible. The mandible was then forced to always close in this forward position by means of "bite plates" of various forms, until finally it became so modified in form and in relation to the temporomaxillary articulation that it would no longer move distally, as before. Notwithstanding that the result in occlusion and facial balance was very ideal, the difficulty of keeping the mandible in the forward position was so great as to cause some to doubt its even being a possibility. Yet that it was accomplished in some favorable cases after most prolonged and difficult retention is well known. In reality we now accomplish in a far quicker and easier manner the same ideal results by means of the intermaxillary force as previously described.

As previously stated there were formerly much in vogue two other plans for establishing harmony in the sizes of the dental arches in cases belonging to this division of this class. The first, and one which has been longest practised, necessitated the sacrifice of two upper premolars, usually the first, followed by the retraction of the canines and incisors, in order to harmonize the sizes of the dental arches, and many

[1] This patient was treated in 1904 by Dr. Guilhermena P. Mendell, of Minneapolis. When first reported it was the youngest case on record in which anything like such extensive malocclusion of the deciduous teeth had been corrected.

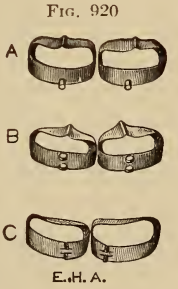
are the devices which have been employed for this purpose. Some of them are extremely crude and defective, especially in the principles of anchorage, usually relying upon the stability of the first molars for overcoming the resistance of the teeth to be moved, the result in nearly every instance being the displacement mesially of the anchor teeth, usually more than the anterior teeth were moved distally.

Fig. 919



Other devices depended on a combination of molar and occipital anchorage, with better results. The writer's appliances for accomplishing the retraction of the incisors and canines are shown in Figs. 775 and 919. It will be seen that stationary anchorage of the molars is combined with occipital anchorage, making use of the traction-screws, as in Fig. 801, in combination with the arch *B*, the distal ends of the arch being inserted in short sheaths attached to the long sheaths of the traction screw. The anterior part of the arch *B* is kept in contact with the labial surfaces of the incisors (upper) by being made to rest in notches formed in the united ends of plain bands on these teeth, made from the band material F, as shown in *C*, Fig. 920.

Fig. 920



Force derived from the headgear through heavy elastic bands is transmitted to the ball-and-socket joint between the traction bar and the arch *B*, to the centre of the arch *B*. Additional force from intermaxillary anchorage may also be enlisted by use of the rubber ligatures made to engage sheath-hooks on the arch *B* and the anchor-bands on the lower molars, as already described in the first plan of treatment. Although the device here shown is unquestionably the most simple and efficient for carrying out this plan of

treatment, yet the principle of treatment itself is obviously wrong and ought rarely, if ever, to be employed, for at best it is only palliative,

Fig. 921

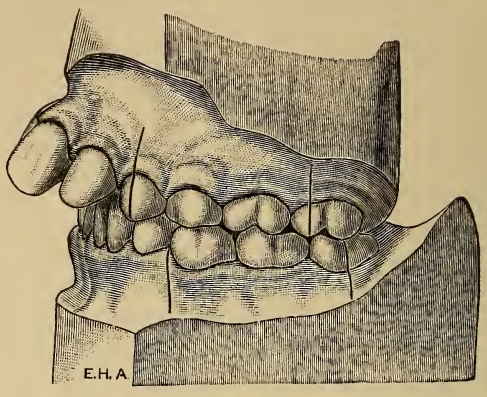


Fig. 922



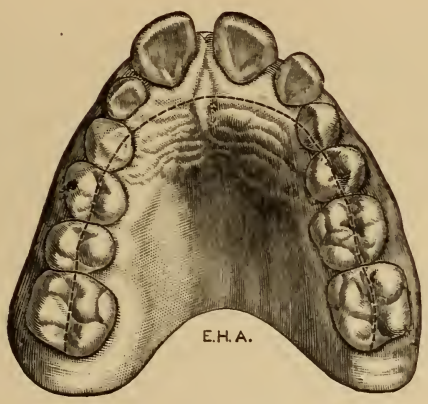
creating one deformity to patch up another. There is always a strained and unnatural look given to the mouth, following this plan of treatment.

The writer has yet to see a single instance where the facial lines have been much improved over their former condition, and in some instances they had been made radically worse after treatment by this method. Fig. 742 shows the facial lines of one patient after such treatment.

This plan of treatment was, of course, excusable before the introduction of the Baker anchorage; in fact, it was then the only one that might safely be relied upon; but with the progressive orthodontist it can no longer be in favor, and we believe it is destined to become obsolete.

Another plan of treatment, introduced by Dr. Norman W. Kingsley, consisted in what he termed "jumping the bite," or shifting the position of the mandible and lower teeth from distal to normal occlusion (which anyone with distal occlusion can do voluntarily), and holding the jaw in this position by some form of mechanical device until either the jaw or temporomaxillary articulation, or both, had supposedly been modified to be in harmony with the teeth in their corrected occlusion or normal relations, when, it was supposed, there would be no recurrence of the former condition.

Fig. 923

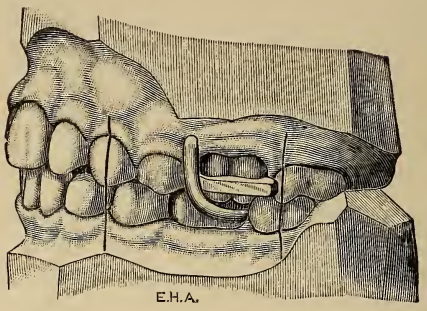


In order to establish harmony in the occlusal inclined planes in this manner it was, of course, necessary to first place the teeth of the upper arch in harmony with their normal line of occlusion; that is, widening this arch somewhat in the region of the canines and premolars, and moving lingually the protruding incisors, which was done by various forms of mechanical devices.

This plan of treatment has occasioned much controversy, its practicability being doubted by many and stoutly defended by others. The great advantage of the method, were it practicable, over the one last described must be apparent to all, for, in addition to the first requisite in the treatment of malocclusion, the complete restoration to normal occlusion, it made possible the restoration of the chin and lower jaw to

harmony of balance with the rest of the face. No wonder it should have strong advocates, especially by those of Dr. Kingsley's type, who

Fig. 924



set much store by the artistic balance of the face. But, as we shall see, one important phase of the conditions contingent on this plan of treatment has been overlooked by the advocates of this plan. The following case, which was treated after this plan, will illustrate this. The case

Fig. 925



was that of a boy aged nine years. It will be seen from the malocclusion (Fig. 921) and the facial lines (Fig. 922) that the case is one

typical of this division of this class. The first permanent molars on both sides had erupted and locked in complete distal occlusion, with the usual narrowed upper arch and protruding upper incisors.

Fig. 926



Fig. 923 shows the occlusal aspect of the upper arch, and the dotted line in the engraving indicates the relation of the lower teeth.

Fig. 927



The teeth of the upper arch were moved into correct relation with their proper line of occlusion, which resulted in the shortening and

widening of the arch. The lower jaw could then be moved forward, and, upon closing, the teeth were in normal occlusion, as shown in Fig. 924. Closure in this position was compelled by the devices shown in the engraving and already described in retention.

This plan of retention was continued for a period of two years, being shifted from one side to the other, and occasionally employed on both sides at the same time. It will be noted by studying the profile of the young man's face (Fig. 925) that the lower jaw has been carried well forward, and that it is now in excellent harmony with the rest of the face, in marked contrast with the weak, receding chin shown in Fig. 922.

Gradually retention was discontinued, and the deciduous molars were lost and replaced by their successors, each locking normally with its antagonist. Some two years after all devices for mechanical retention had been removed, a study of the occlusion of the teeth, as shown in the correctly made models (Fig. 926), revealed normal occlusion. The writer felt positive he had succeeded in "jumping the bite." Meantime other cases had been carried on with equally good results. But an important change had been taking place in this case, probably from the very beginning of retention, and yet unnoticed. This change was discovered by a comparison of the profile of the young man at the age of fifteen (Fig. 927) with the photograph of his profile taken at the time of completion of treatment (Fig. 925). It clearly showed that instead of the temporomaxillary articulation having been permanently modified to be in harmony with the new position of the mandible, that in reality the mandible had gradually worked back into its old relations, and that, too, without displacing the normal relations of the inclined occlusal planes, the explanation of this being that the crowns of the upper teeth had to a certain extent been tipped distally and the crowns of the lower teeth more or less mesially; or, in other words, there had occurred in this two-year period of retention what we now aim to accomplish and do accomplish in a very few weeks with the Baker anchorage.

Inspection of other cases showed like results. In one instance in which retention had been continuous on one side the same result had occurred, as shown in Fig. 926, but on the other side, the retaining device having been lost and not replaced, as the mandible regained its former relations, the teeth also drifted back into their original positions of distal occlusion.

Class II.—Division 1, Subdivision.—Practically the same conditions are met in cases belonging to the subdivision of Division 1, Class II, as are found in Division 1, just described, the only difference being that on one side only have the teeth locked abnormally, or the lower in distal occlusion, the teeth on the other side being locked in normal occlusion.

There is the same narrowing, only less in degree, of the upper arch, with incisors protruding, in many instances quite as much as in the full division, and with facial lines marred just in proportion to the extent of the malocclusion.

The treatment indicated is the same as in all cases of malocclusion, namely, the establishment of the normal relations between the inclined occlusal planes. In this class of cases this is brought about in precisely the same manner, and with the same combination of appliances used in the same way, as in cases belonging to the full division, or in distal occlusion on both sides, except that the sheath-hook and rubber ligatures for shifting the upper teeth distally and the lower teeth mesially are used only on the side of the distal occlusion, although sometimes, in order to maintain the proper balance of the appliance, only gentle intermaxillary force becomes necessary as well on the normal side.

Of course, if there is required, and there often is, any individual tooth movement in either of the dental arches, they are effected at the same time as the distal shifting of the upper teeth and the mesial tipping of the lower by means of spurred bands and wire ligatures, as described in the treatment of cases belonging to Class I.

The teeth that have been moved are retained in the same way as described for cases belonging to Division 1, Class II.

Fig. 928



Class II.—Division 2.—It will be remembered that in cases of malocclusion belonging to this division of Class II, as in those of Division 1, the teeth of the lower arch are in distal occlusion in both its lateral halves. The upper arch, unlike that in cases of Division 1, which is abnormally long and narrow, is shortened, with incisors bunched and overlapping, as in Fig. 928, to approximately harmonize in size with the anterior part of the lower arch. Unlike the conditions of Division 1, the lower incisors are not elevated in their sockets, owing, probably, to their greater use, and there is normal respiration and lip function, with a far more normal vault and width of arch, but the result of distal occlusion and recession of the jaw and chin greatly mars the facial lines, as shown in the face in Fig. 736.

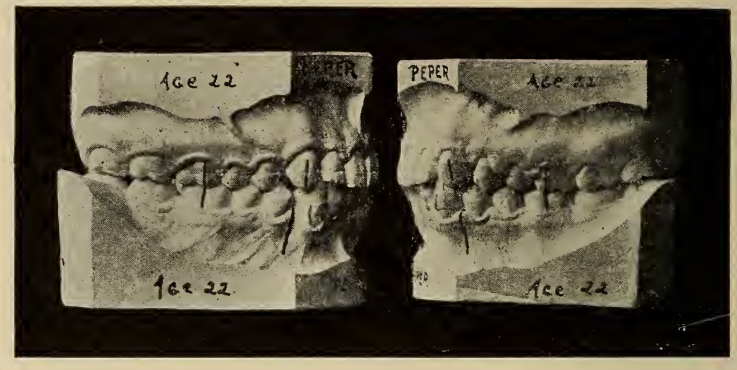
The logical plan of treatment in this, as in all cases of all classes, and one that is thoroughly practical and not difficult of accomplish-

ment, especially if treatment be begun early and intelligently managed, is the establishment of normal occlusion of the teeth.

As cases belonging to this division require the same movements of the molars, premolars, and canines as do cases belonging to Division 1 of this class, they are accomplished in exactly the same way and with the same combination of appliances.

But the upper incisors, being more or less retruded, bunched and overlapping, their torsal and labial movements are required, and these are effected at the same time the upper molars and premolars are moved distally, by means of plain bands, spurs, and ligatures engaging the expansion arch, precisely as would be done in cases belonging to Class I (see Fig. 769), the mesial movements of these teeth reciprocating force to the molars and making more easy the movement of both.

Fig. 929



If the positions of the lower incisors require corrections, this is accomplished by bands, spurs, and wire ligatures in connection with the lower expansion arch, at the same time the mesial movement of the lower molars, premolars, and canines is effected.

Both upper and lower incisors are retained in the same manner as for the same teeth in Class I, similar tooth movements having been performed, and the molars, premolars, and canines as previously described for the retention of these teeth in Division 1, Class II.

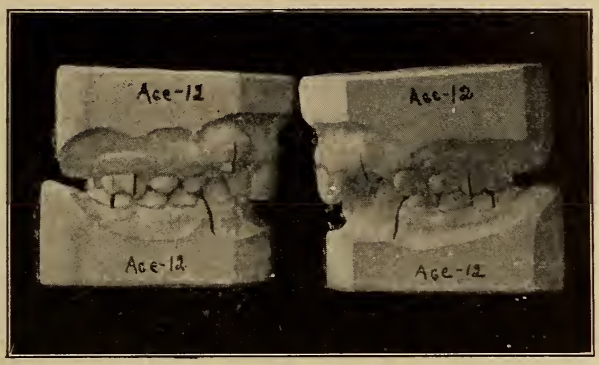
Although these cases are apparently more complicated than those of the first division, usually they are more easily treated.

Again, as the patients are normal breathers and keep the mouth closed the requisite amount of time, the time of retention of the molars by mechanical devices is shorter, as the normal locking of the cusps—nature's most important retaining device—thus becomes more effective.

Fig. 929 shows the case corrected and at the time of adjustment of the retaining devices, and the face in Fig. 737 shows the result of treatment on the facial lines

The case here shown is one purposely selected as being not only typical, but also of unusual difficulties, owing to the large size and density of the jaws, and the full complement of unusually large teeth, all of which were in malocclusion and required to be moved in order

FIG. 930



to carry out this plan of treatment, yet the mesial movements of all the lower teeth and the opposite movement of the upper molars, premolars, and canines, together with the necessary individual movements of the incisors and canines, were effected simultaneously and in about three months' time.

FIG. 931



Of course, the golden time for the treatment of this case was at, or soon after, the time of the eruption of the first molars, and the difficulties of treatment have gradually increased with the advance of years. It is quite probable that all that would have been necessary at that

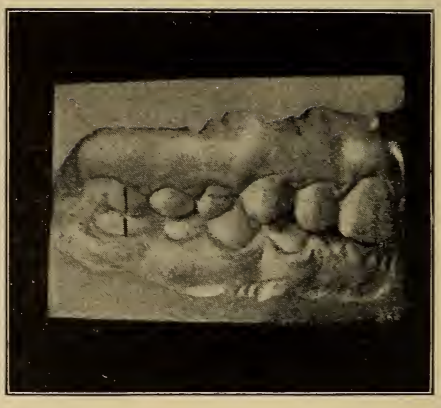
time would have been simply the directing into normal relations of the first molar teeth.

Fig. 930 shows the malocclusion of another case from both right and left sides, this patient being much younger, but the treatment being after the same plan.

Fig. 931 shows the facial lines of the patient before treatment and how greatly they were marred by the pronounced malocclusion.

Fig. 932 shows the case at the time of the adjustment of the retaining devices, and it will be noticed how short the bite is in the incisive region, and this gives us an opportunity to point out the importance of establishing the normal length of overbite, and while this condition may be met in the treatment of any case of any class, it is, as Dr. Kirk has well said, "of quite as much importance that the proper length of bite be established as it is that any other phase of malocclusion be corrected."

Fig. 932



Where the overbite may in some instances be due to the supra-eruption of the incisors, it will in most instances be found to be due to the infra-eruption of the first molars, and usually the lower ones.

Naturally the elevation and retention of the lower first molars by mechanical means would seem to be the correct solution of this problem, and while their elevation is not difficult to accomplish, yet the writer has never been successful in maintaining the teeth in this position, even though they had been mechanically retained for many months, for upon the removal of their mechanical support they would gradually settle back into their original positions and the overbite become as before. The reason for this was puzzling, yet when we remember the great force received upon these teeth from occlusion and the great disturbance in the attachment of the fibers in the peridental membrane, and especially the immense number of suspensory fibers which have been recurved upon themselves in the elevation of these teeth, we can understand how long a period of time must be required before there can be a recon-

structed, normally functionating membrane and osseous attachments, especially in patients nearing maturity. So the plan that the writer has found to be most satisfactory is one that has long been in use, namely, to separate the bite by a vulcanite plate, thickened in front and covering the vault of the arch, with depressions in the plate for the reception of the lower incisors so that the full thrust of the jaw may be received upon these teeth instead of upon the molars. The plate is prevented from being forced upward in front, and from being loosened in the rear, by hooks firmly embedded in the plate and made to engage the cutting edges of the upper incisors. When properly adjusted this plate should relieve all strain from the opposing first molars which are separated at least three thirty-seconds of an inch. If constantly worn for from six months

FIG. 933 FIG. 934



to a year the molars will have become lengthened and the proper length of bite established. The result of this method of treatment is shown in the fine balance that has been given to the facial lines (Figs. 933 and 934) and in the improvement in the occlusion (Figs. 935 and 936).

It may be well to note that in nearly all cases belonging to Class II there is more or less of an abnormal overbite, sometimes most pronounced, but it is gratifying to note that this will in most instances disappear as the crowns of the teeth are tipped into their normal positions, or their normal angles of inclination established.

While numerous simpler cases belonging to this division might be reported here, this seems unnecessary, as the stories they might tell in occlusion and art and in the methods of accomplishing the various

tooth movements are embraced in the cases already reported, and if these be understood the treatment of simple cases should offer no difficult problems.

Fig. 935

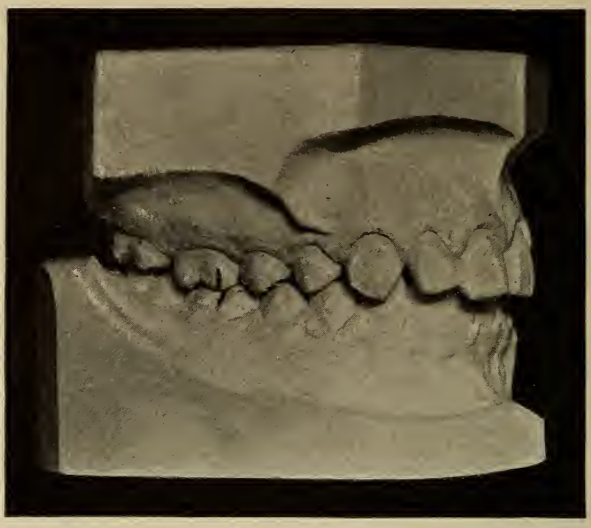
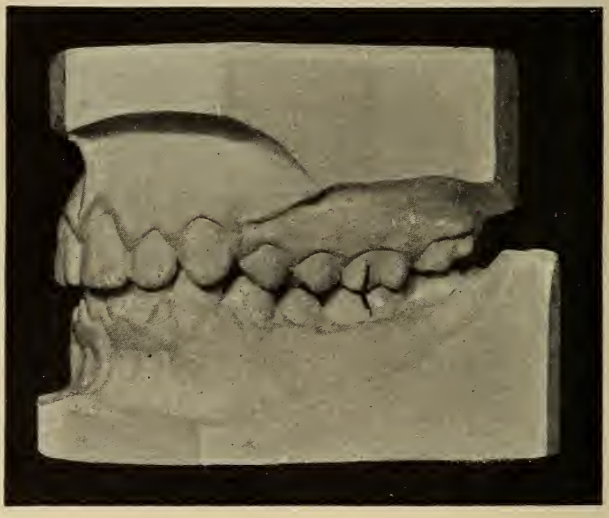


Fig. 936



Class II.—Division 2, Subdivision.—In cases belonging to this subdivision the conditions and indications for treatment on the abnormal side are similar to those in Division 2, Class II, just described, the differences being, like those of the subdivision of Division 1, Class II, that one of the lateral halves of the dental arches only is in distal occlusion, the lower first molar on this side failing to lock normally; but, as it

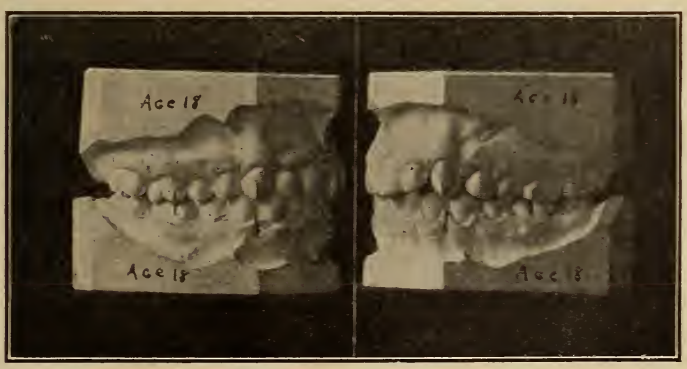
erupted, was shifted into distal occlusion, necessitating the abnormal locking of each succeeding tooth that erupted on that side, until we have inharmony in the sizes of the arches, the upper being larger to the extent of one premolar tooth, and the compensation being in the overlapping of the upper incisors and canines, as shown in the typical case, Fig. 937.

Fig. 937



The treatment clearly indicated was the correction of the malposition of each tooth in each arch; at the same time the relations of the dental arches were made to harmonize by the movement mesially of the lower teeth on the abnormal side one-half the width of a premolar, while the upper incisors, premolars, and canines were shifted distally to the same extent by the use of the expansion arches, D bands, etc., in connection with the intermaxillary anchorage, all as described in the treat-

Fig. 938



ment of cases belonging to Divisions 1 and 2 of this class. The result is shown in Fig. 938.

Fig. 939 shows the facial lines before treatment, and Fig. 940 shows how greatly they have been improved as a result of correcting the malocclusion. The weak appearance of the lower part of the face, through

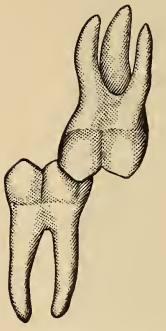
its recession, has been strengthened and almost perfect balance of the mouth with the rest of the features has been established.

A former plan of treatment by the writer for these cases is shown in Fig. 821, in which harmony in the sizes of the arches was established by extracting the first upper premolar on the abnormal side and retracting the canine, and at the same time the incisors and canines were rotated into correct alignment.

FIG. 939 FIG. 940



The combination of the traction-screw and expansion arch, wire ligatures, etc., is well shown, and, indeed, this is one of the most thoroughly efficient devices for performing tooth movements that is anywhere found in the history of orthodontia, as each part most perfectly braces and assists reciprocally the other parts of the device in effecting the various tooth movements, and it was the occasion of much pride with the writer. But by this plan of treatment mutilation was necessary, with all its attendant evils in occlusion, tongue restriction, and facial deformity, and since normal occlusion is now so easily established by intermaxillary force, as previously described, its use is rarely, if ever, required.

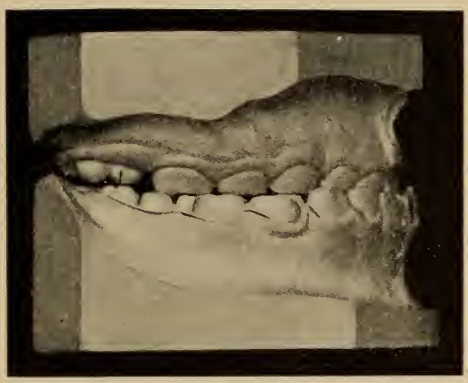


E. H. A.

Class III.—In the treatment of cases belonging to Class III, the degree of our success, more than in any other orthodontic work, depends on beginning treatment early. This form of malocclusion usually begins at about the time of the eruption of the first permanent molars, although it may begin earlier, and, as the writer first pointed out, it is always associated in its beginnings with enlarged tonsils, the habit of protruding the mandible probably in

some way affording some relief in breathing, which habit, it seems reasonable to the writer to believe, is a potent factor in the locking of the first permanent molars, as they erupt, into mesial malocclusion. And when once the mesio-buccal cusp of the upper first molar begins to engage the distal incline of the disto-buccal cusp of the lower first molar, the result

FIG. 941



mechanically is to force the mandible forward on each closure of the jaws. This in time forces the deciduous teeth into malocclusion, as well as each succeeding permanent tooth as it erupts, thereby enlisting the other inclined planes to act out of harmony with nature's intended plan, and to assist in accelerating the forward movement of the mandible. Not only this, but the bone is thus stimulated to develop abnormally, which

FIG. 942



is probably furthered to no small extent by the added stimulus of the muscles in their abnormal relations with it.

So, after the lower first molars are locked in mesial occlusion and the forces perverted, the progress must be and is rapid, only a few years being necessary to develop by far the worst type of deformity

the orthodontist is called upon to treat; and when the case has progressed until the age of perhaps sixteen, or after the jaws have become developed in accordance with the malpositions of the teeth, all excepting the third molars having erupted by this time, the case has usually passed beyond the boundaries of simple malocclusion and into that realm of marked complications, namely, bone deformities, with little possibility, with our present knowledge of the subject, of affording much relief by orthodontic measures.

If these cases could receive prompt attention at the important period of the eruption of the first molars, the throats properly treated, and the first molars mechanically assisted into normal relations, and there compelled to remain by delicate yet efficient retention for a few months, these unsightly deformities would never develop.

FIG. 943



There may be, and doubtless are, other factors that enter into the production of these as yet but imperfectly understood deformities; but we are convinced that they are of minor importance to those we have mentioned.

The time-honored shifting of these conditions on to heredity and supposed degenerate tendencies no longer satisfies or carries much weight.

Figs. 941 and 942 show the malocclusion in the case of a child, aged six years, who was, and had been for some time, a sufferer from greatly enlarged faucial tonsils. The first permanent molars are erupting, and the lower ones, in taking their positions, will soon become fully locked in mesial occlusion. This is a fair example of the beginning of all these cases.

The deciduous teeth are rapidly becoming harmonized to the abnormal occlusion, the lower incisors now closing mesially to the upper incisors. Thus the tendency is clearly indicated and its effects shown on the facial lines (Fig. 943), and this condition has developed rapidly, the contour of the baby face being thus changed in but a few months.

Fig. 944



The treatment was simple and easy. Small D bands were placed upon all four deciduous second molars and the plain expansion arches (small) were adjusted, as per combination shown in Fig. 812, and force exerted by means of the delicate rubber ligatures made to engage the sheath-hooks on the lower arch, which were placed well forward, or

Fig. 945



opposite the lateral incisors, and the other ends stretched over the distal ends of the sheaths of the upper anchor-bands, the result being that in a very short time the teeth were shifted into normal relations.

The case was retained by means of two delicate spurs soldered to the lingual surface of delicate bands on the upper deciduous central

incisors, these spurs extending downward and somewhat forward in front of the lower centrals, thus compelling the normal closure of the mandible,

Fig. 946



and Figs. 944 and 945 show the occlusion at this stage, the lower deciduous laterals meantime having been lost. The pronounced change in

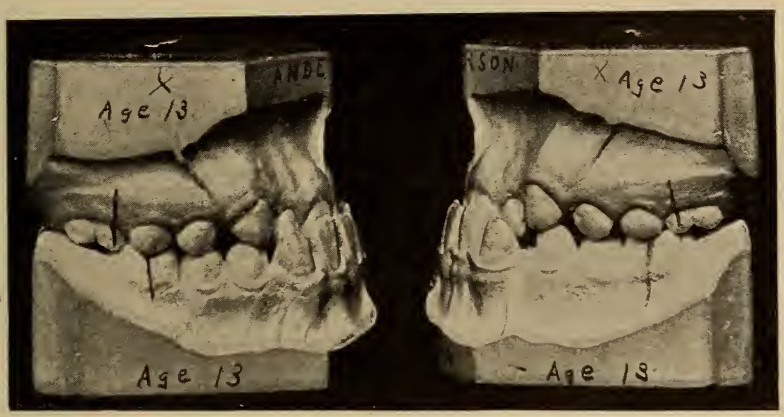
Fig. 947



the facial lines as the result of this modified occlusion is shown in Fig. 946.

The eruption and locking of the first permanent molars was now complete, and the deciduous upper incisors, with their retaining bands and spurs, were lost through the natural absorption of their roots a few weeks later, and, although several years have since elapsed, the occlu-

FIG. 948

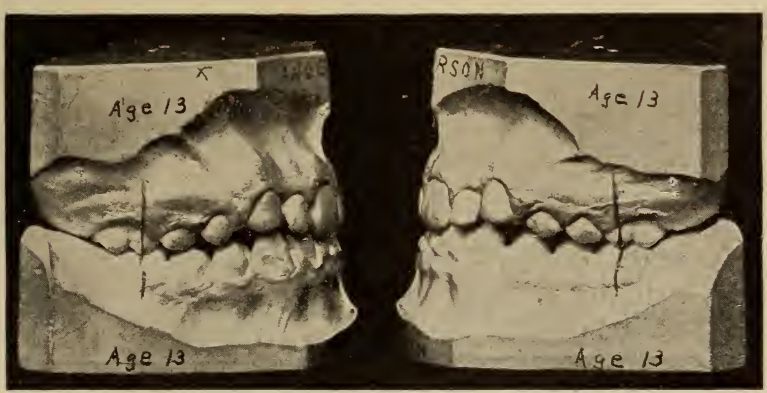


sion is practically faultless and the facial lines are in excellent balance, as shown in Fig. 947.

Fig. 948 shows the malocclusion in another case of a patient seven years older, in which the natural progress of the deformity is clearly shown.

The result in the inharmony of facial lines is shown in Fig. 738.

FIG. 949



The treatment clearly indicated was to establish harmony in the sizes of the arches and normal relations of the inclined occlusal planes. Without the intermaxillary force this would have been impossible, but with it the desired changes were effected, and that, too, quite speedily.

The same combination of appliances as that described for the last case was also used in this. The force necessary to shift mesially the upper teeth was reciprocated to move distally all of the lower teeth. It

Fig. 950

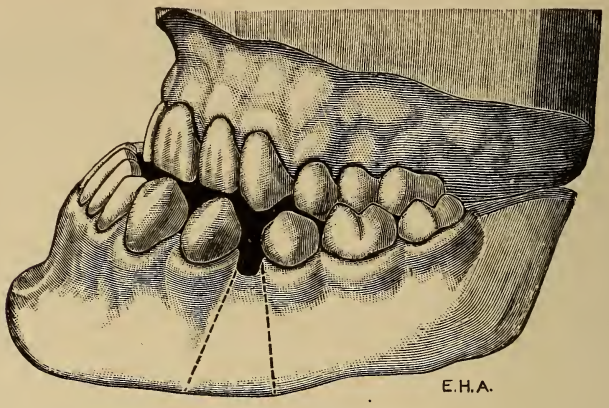


Fig. 951



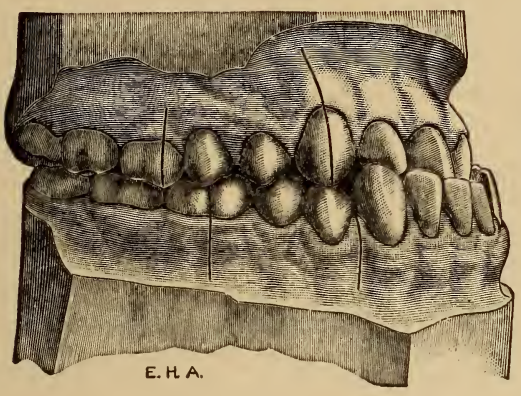
is quite probable that the mandible was also moved distally somewhat. In fact, this is shown in the facial lines after treatment (Fig. 739), but the principal change was in the positions of the crowns of the teeth after three weeks' treatment, shown in Fig. 949.

No effort was made to establish better relations between the premolars, knowing full well that as these teeth continued their eruption they would be forced more and more into their normal relations through the influence of their inclined occlusal planes.

The retention was effected as described in the section on retention for cases belonging to Class III.

Any purely orthodontic treatment in such pronounced cases as that shown in Fig. 950 (facial lines in Fig. 951) is a waste of time both of patient and operator. The only possible relief would be by performing the writer's operation known as "double resection of the jaw,"[1] but as that comes under the realm of surgery, its consideration does not properly belong here.

Fig. 952



Even in such cases as that shown in Fig. 952, in which the malocclusion has never passed beyond simple mesial occlusion, yet at this age of the patient (twenty-five years) the jaws and muscles have become fixed in their abnormal development, and the result, after many months of patient, persistent treatment, will usually be found to be most discouraging and unsatisfactory. They are good cases to avoid.

We have elsewhere given our views relative to the use of the chin retractor and occipital anchorage in connection with the treatment of these cases, and how they have practically become superseded by the intermaxillary anchorage. The writer no longer finds value in their use, although there is the barest possibility that they may still in some instances have use as an auxiliary to the intermaxillary anchorage.

Class III.—Subdivision.—As cases belonging to the subdivision of Class III are in unilateral mesial occlusion, the treatment clearly indicated, especially in young patients, is after the same plan we have

[1] For the consideration of this operation see the writer's Malocclusion of the Teeth, seventh edition.

described for the full division, exerting force, however, only on the side that is in mesial occlusion.

In this short treatise the writer has aimed to point out a simple, logical system not only of diagnosticating malocclusion, but also its treatment, from the simplest to the most complex cases—and all from the basis of normal occlusion.

And finally, orthodontia is now one of the well-recognized specialties of medicine, and in its practice the possibilities for adding to the health, beauty, and happiness of humanity are so great as to make it a most inviting field. Yet it must be remembered that the difficulties in the practice of orthodontia are such that only those who have an aptitude for the work and will study it broadly and thoroughly will ever be successful in its practice, but for such a limitless field and prompt recognition is waiting.

Orthodontia should be taught and practised as a distinct specialty, for there is no specialty in medicine with more clearly defined boundary lines. To the mere smatterer it is a most unpromising and unprofitable field of labor, but to those with an aptitude and liking for the work, who by study and patient endeavor master it, orthodontia is for many reasons a most ideal specialty, and offers opportunities not now approximated by any other in medicine.

Malocclusion of the teeth is so prevalent, and its intelligent treatment followed by benefits so pronounced in the health, happiness, and beauty of the patient, that although it is the newest specialty in medicine it is destined soon to be recognized as one of the most important.

CHAPTER XXII

DENTO-FACIAL ORTHOPEDIA

By CALVIN S. CASE, D.D.S., M.D.

INFLUENCE OF THE TEETH ON THE PHYSIOGNOMY

In the developmental processes of animal life the teeth have probably been more influential than any of the other organs in shaping the bones of the head—especially in determining the physical characteristics of the physiognomy. The physical shape and structure of the jaws conclusively show the influence that the teeth have exerted in different species in response to nature's effort to propagate that which would best subserve them in the performance of their functions. The importance of the teeth, therefore, and their inherent demand upon surrounding anatomical structures for proper means of development, sustenance, and use, is evidence that they exert, during development, a more or less immediate influence in determining the size and shape of the maxillary bones, and thus indirectly are extensively influential in characterizing the individual shape of the human face.

Often the position of the anterior teeth and alveolar process is such as to impress upon the contiguous features, even in repose, certain conditions which vary from a slight imperfection in esthetic contour to a most distressing facial deformity. Nor are these dento-facial imperfections always wholly due to a malposition of the teeth, so much as to a lack of normal symmetry in the size or shape of the maxillary bones upon which so large an area of the face is dependent for its contour.

Causes.—These conditions may have arisen from the direct inheritance of a parental deformity, or from the inharmonious union of undiluted types. It is equally true that the offspring of inharmonious types often results in symmetrical conditions which neither parent possesses.

Among local causes, or those which operate after birth in the production of facial imperfections, may be mentioned habits, impaired dentition, delayed and injudicious extraction of the deciduous teeth, and diseases of the nasopharyngeal passages, causing a lack of normal development of adjoining bones, often accompanied with mouth breathing, with its far-reaching effects.

The influence of the teeth during the time of their eruption (producing on the one hand the excessive pressure of large teeth and concomitant alveolar development, and on the other a lack of pressure from

an irregularity or injudicious extraction) in effecting a change in the inherent shape or size of the maxillary bones beyond that which the alveolar process is forced to assume to accommodate them, has been a question of considerable controversy.

While it is of common observation that bones are retarded and even permanently stunted in their growth development by both natural and artificial causes, and thus made to assume a diminished size, I think it may be stated as a fact that there is no authentic record of bones having been made to grow, in the individual, appreciably larger or longer than the normal size, by artificial force.

By the early removal of the causes of non-development—as in the removal of adenoids, which have retarded the development of the superior maxillæ and other bones—the affected bones may develop to their full normal size after the cause is removed, if properly aided by artificial stress.

It is reasonable to assume that artificial force cannot cause the production of that which is commonly seen to be apparently impossible by the strongest of the natural physical forces operating during the early stages of childhood development and through adolescence. I refer to those commonly seen dental protrusions, unimaxillary and bimaxillary, which evidently assume this position because the teeth are too large for the natural size of the jaws in which they are placed. The pressure of erupting teeth, as is the force exerted by all natural growth, is far greater than one would imagine who had not carefully observed its effects. Why is it then that this great pressure of the erupting permanent teeth, crowding their way in between the rami and the labial arch does not cause the disto-mesial enlargement of the body of the mandible, so as to extend the chin forward somewhat in harmony with the protruded position of the teeth? If this were possible we would not so frequently see the appearance of receding chins occurring with people whose mandibles are in full harmony as regards size, with the balance of the features; the effect being purely because of an excessive abnormal protrusion of the lower teeth and alveolar process.

With bimaxillary protrusions the dentures will frequently be found in normal occlusion, alignment, and in proper arch width with the production nevertheless of a decided abnormal prominence of the mouth, extending over the entire dento-facial area (Fig. 953).

This is a question of the greatest importance to consider in the contemplation of moving the lower dentures of young children forward with the intermaxillary force to place them in normal occlusion with protruded uppers—an operation that is questionably advocated and unfortunately extensively and indiscriminately practised today.

If one could be sure, at these early stages, that the lower dentures were destined to be retruded in relation to the mandible and that this forward movement would not ultimately result in a receding chin effect

it would be excusable and demanded. It unfortunately happens in a large proportion of these cases that the disto-mesial malocclusion of

Fig. 953



the buccal teeth is due solely to an inherent protrusion of the upper dentures, which in the operation of adjusting the occlusion to normal with the intermaxillary force, the uppers are retruded only one-third or at most one-half as much as they should be to correct the facial

Fig. 954



deformities; the whole resulting in bimaxillary protrusions stamped upon many faces for life whose features might have been handsome

had the upper first or second premolars been extracted and the labial teeth fully retruded, with no movement of the lower dentures and upper buccal teeth, except that required to adjust the closure to a perfect interdigitating occlusion (Fig. 954).

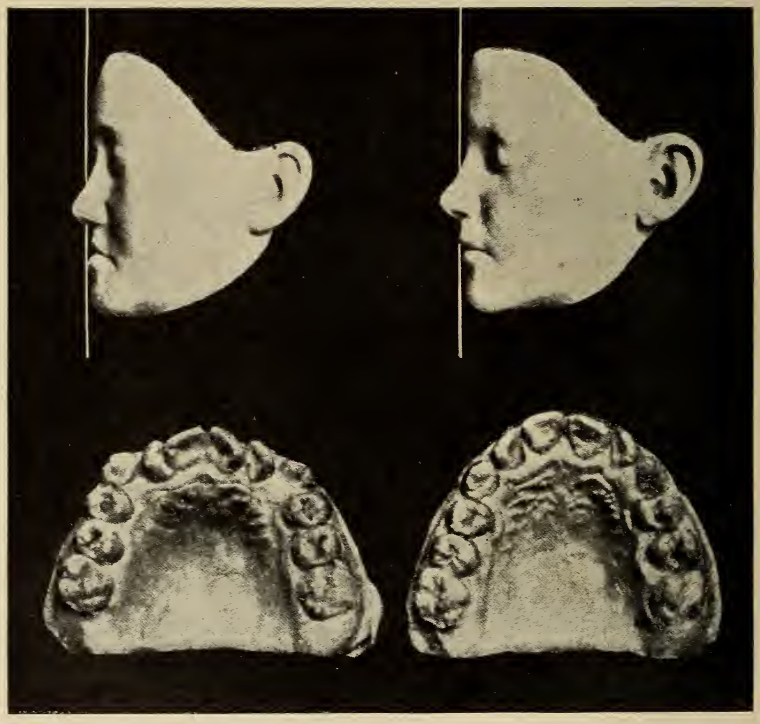
Fig. 955



Irregularities of the teeth caused by diseases of the naso-maxillary sinuses and, secondarily, by a lack of development of the maxillary bones, pertains directly to the upper jaw, although the lower teeth may also be forced into malposition through the influences of imperfect occlusion, and even the mandible itself may be changed in shape by the concomitant mouth breathing, causing an open-bite malocclusion.

With the primary cause of these conditions removed at an early age, the retarded development of the superior maxillæ may be made to assume

Fig. 956



its normal size and shape. A peculiarly fortunate possibility arises from the fact that a retruded incisive portion of the maxillæ may be

forced forward to a normal position with a bodily protruding movement of the incisor teeth. It would seem that it was only the alveolar ridge that moved, were it not for the fact that in those cases where the end of the nose is carried backward through a lack of forward growth development of the incisive process it is commonly carried forward and straightened

Fig. 957



Fig. 958



in this movement (see Figs. 968, 973, and 978). When it is remembered that the end of the nose is supported by the cartilaginous septum attachment to the nasal spine of the superior maxillary bones, it will be seen that the incisive portion of the maxillæ proper must move to carry the end of the nose forward as it frequently does.

The bodily forward movement of the labial teeth is now an operation that is quite as easily accomplished with the proper apparatus as any

Fig. 959



Fig. 960



of the other extensive movements of regulating. For patients not older than twelve or fourteen years, the entire incisive alveolar ridge is commonly carried forward with the teeth.

This is well shown in the accompanying illustrations made from the models of a face when presented at twelve years of age, showing a decided retrusion of the upper incisor teeth involving the entire incisive alveolar

ridge. Other parts of the jaws and teeth were in normal size, relation, and occlusion.

The illustrations on the left show different views of the case at the beginning of the operation, and those on the right after the teeth and alveolar ridge had been bodily protruded with the contouring apparatus shown in Fig. 961.

This cut was made from a photograph of the apparatus which the patient wore, and which after removal was placed on her dental casts as shown.

In dental orthopedia we possess the great advantage over general orthopedia of applying force directly to the bone itself, through the medium of the teeth, without the intervention of the soft and sensitive tissues.

FIG. 961



The teeth embedded in the alveolar process that in turn is firmly united to the true bone may be considered, when in the grasp of a regulating machine, as an integral part of it, firmly and directly attached to that part of the bone we desire to move, and capable of exerting the quality and direction of force the machine gives to them.

This force being applied unitedly to a number of teeth standing side by side, the surrounding and contiguous bone—which is largely a cancellated structure—is carried bodily in the direction of the force; not by the fracture of its substance or to any great extent by a metamorphosis of tissue, but by the bending, condensation, and elongation of its cellular structure; the whole adapting itself to a new form, in which position the immediate interstitial tension of its particles is soon relieved and brought to equilibrium by nature—although it may require to be held in that position for many months before there is an entire relief from the inherent tendency to return to the former position.

Dento-facial Diagnosis.—In contemplating the treatment of a dental irregularity a careful study of the physiognomy in different attitudes

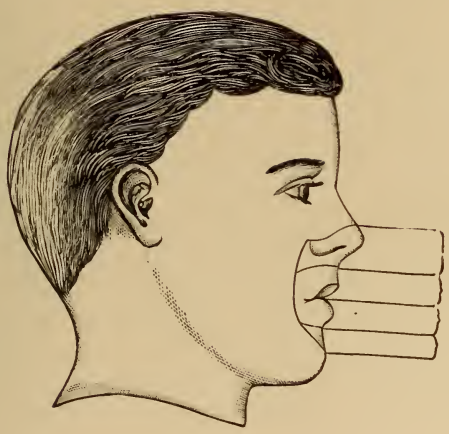
of expression should be made, with the view of determining the relative position of teeth and facial contours. The value of a careful preliminary facial examination and comparison cannot be overestimated, for it is often the only guide to correct treatment.

For instance, since it has become possible to expand or retract the anterior portion of the upper apical zone with the surrounding bone in which the moving roots are embedded, we are no longer confined to the possibility, and frequent questionable propriety, of permanently moving the lower jaw forward or backward to correct a facial deformity which pertains exclusively to the upper maxillæ and middle features of the face.

PRINCIPLES OF FACIAL ORTHOPEDIA

The portion of the human face that it is possible to change with a dental regulating apparatus may be said to lie between two diverging

FIG. 962



lines which arise at a point below the ridge of the nose and curve downward to inclose the alæ and depressions on either side; thence laterally to encircle a portion of the cheek, and downward to inclose the entire lower lip and labio-mental curve (Fig. 962.)

Within this ovoidal area the slightest change of muscular movement expressive of the emotions will produce an apparently marked effect upon the entire physiognomy. The same is true of any physical imperfection of contour, particularly around the mouth. It is here that an inherited or acquired lack of symmetry in the size, shape, or position of the teeth and jaws produces those marked changes of facial contour which

characterize the several classes of dento-facial deformities. This area may be termed the " changeable area" in contradistinction to the more stable features, or "unchangeable area."

For convenience of ready reference, the features in that portion of the changeable area which are bounded laterally by the naso-labial lines may be divided into four segments as shown.

In the preliminary examination of the physiognomy from a purely esthetic standpoint with a view of correcting a dento-facial deformity or imperfection, by applying force to the teeth, there are certain prominent features to be especially observed and their relative position carefully noted. These may be divided into two classes: First, those which lie in the unchangeable area, as the forehead, bridge of the nose, malar prominences, and chin; second, those in the changeable area.

The four segments in the latter class shown in Fig. 962 are changeable in their relations to each other, and also in their individual relation to features in the unchangeable area. For instance, it is possible to protrude or retrude the upper portion of the upper lip with the depressions on each side of the nose, the nasal septum, and the end of the nose, without changing the lower portion of the upper lip in its relation to other parts. The same is true of the other segments—in fact, a retrusion of the upper coronal zone and a protrusion of the upper apical zone may be accomplished at the same time (see Figs. 971 and 972).

That part of the cheeks which lies over the premolars and first molars will frequently be rounded out to a fuller contour, although the causes which operate in this result are not direct as in the changeable area proper. The lateral expansion or contraction of the dental arches will often change the contour of the cheeks with no effect upon the labial area, if the anterior teeth remain unchanged in position. Again, a decided retrusion of the anterior teeth and process with no lateral expansion of the arch will invariably result in giving to the cheeks a fuller contour, by relieving the tension of muscular tissues. The same result will often be obtained in closing the characteristic open bite of a mouth-breather by grinding the posterior teeth, and also by retracting a prognathous lower jaw.

In a study of profiles we frequently observe a lack of perfect harmony in the position of the chin. The lower jaw is apparently protruded or retruded, so as to mar the esthetic perfection of the physiognomy, and yet were these same faces examined by a trained observer he would find in a large proportion the lower jaw in perfect harmony with the unchangeable area, and that the appearance of its malposition was an effect due wholly to a protrusion or retrusion of the upper jaw and teeth. In other words, it is a common error to imagine the chin imperfectly posed because it is not in harmonious relations to the other features of the changeable area, instead of comparing it, as we should do, to the more stable or unchangeable features of the physiognomy.

In examining the physiognomy of a patient, the head should be in an upright position, on a line with that of the observer, and the face studied from different angles while in repose and in action.

While looking at the profile in repose the most important thing to determine is the relative position of the chin with the forehead, malar prominences, and bridge of the nose. If its position is harmonious with the unchangeable area and the lower lip is well posed, it indicates that the operation of facial contouring should be performed—if anywhere—upon the upper jaw and teeth. For if the first and second segments are abnormally protruded it will cause a chin to appear retruded that is perfectly harmonious in its relations to the principal features of the face. Again, a retruded or contruded upper arch with a depression of those features which are supported by the superior maxillæ will cause a perfectly posed lower jaw and chin to appear protruded or prognathous; as instanced by many cases illustrated in Section IV, in which the facial effect, before treatment, was that of protruded mandibles, but which were perfectly corrected by a forward movement of the upper incisors.

UPPER PROTRUSIONS

Fig. 963 will serve to partially illustrate this class of dento-facial irregularities. This case is one in which the roots as well as the crowns were protruded.

The intermediate stage of the operation shows conditions after the crowns of the labial teeth had been retruded following the extraction of the first bicuspids, with an apparatus similar to that shown in Fig. 964.

It will be seen that notwithstanding the fact that the retruded force was applied through the medium of the retruding bow at the gingival borders of the front teeth there was left quite a decided prominence along the upper portion of the upper lip.

The final stage of the operation shows the greatly improved facial outlines after the roots had been retruded with an apparatus similar to that shown in Figs. 965 and 966.

If the operation of "jumping the bite" were performed in cases of this character there would no doubt be an improvement of the original appearance of the physiognomy, by bringing the chin and lower lip into more perfect harmony with the upper; but this would not be correct treatment, because, as will be observed, the chin is not far from a perfect position when compared with other features of the unchangeable area.

The principles involved in the correction of this class of facial deformities may be diagrammatically illustrated as follows:

Fig. 967 is a profile view of a typical case of protruded upper teeth. It will be observed that the chin appears retruded.

Fig. 968 shows the improved effect that would be produced by "jumping the bite" in bringing the lower lip and chin into more perfect harmony with the upper; yet not to be compared with that perfection of

Fig. 963

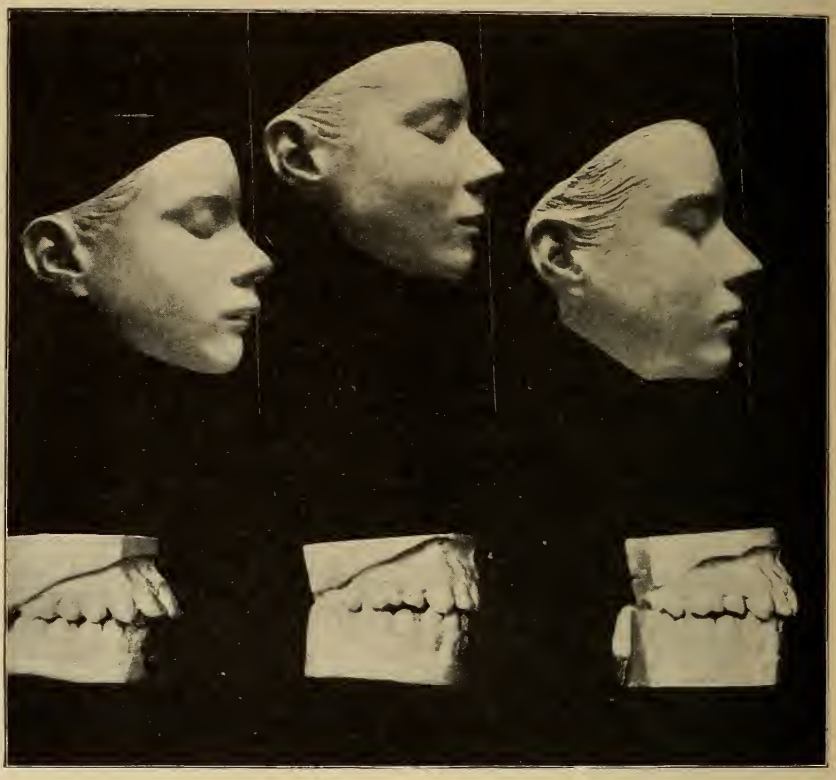
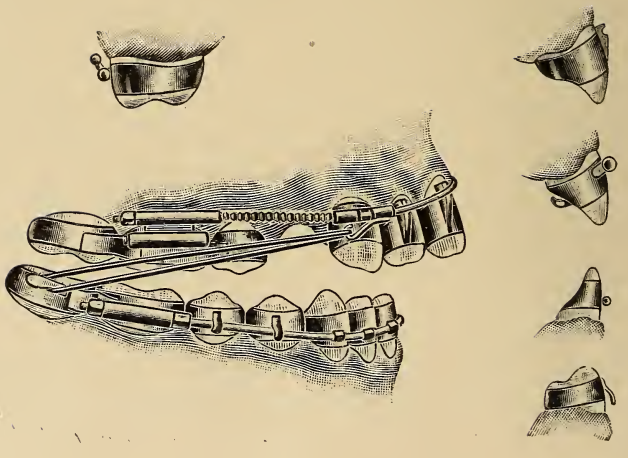


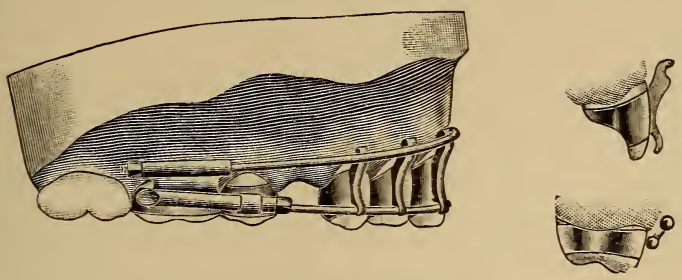
Fig. 964



symmetrical contour shown by Fig. 969, where the chin and lower lip are permitted to remain in their original harmonious position while the end of the nose and upper lip are retruded into harmony with the whole.

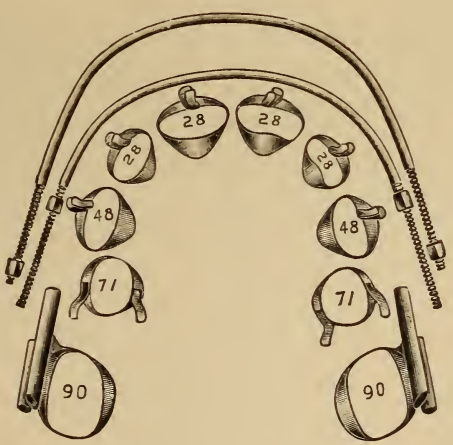
The three faces have been made exactly alike with the exception—as shown by the cross lines—of certain mechanical movements of the

Fig. 965



profile outlines in the changeable area. In Fig. 968 the outlines of the lower zones and chin are placed farther forward, and in Fig. 969 the outlines of the upper zones are carried back, as they would be by a retruding apparatus attached to the teeth.

Fig. 966



In comparing Figs. 967 and 969 the difference in esthetic effect is quite striking, and it is one also which would seem to be hardly possible with so little change in the outlines of a comparatively small area. By cutting a piece of black paper to the exact outline of Figs. 969 and placing it upon Fig. 967 the real and only difference in the two figures can be plainly seen—as in Fig. 970.

When such a change is produced in the features of a human face the difference is greatly enhanced because of the harmonious perfection of other contours not shown by the figures.

Fig. 967



Fig. 968



Fig. 969

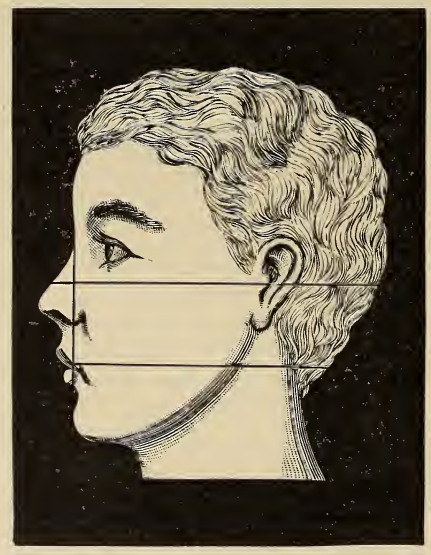
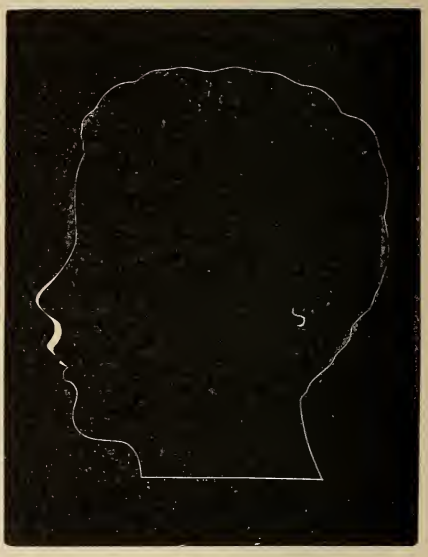


Fig. 970

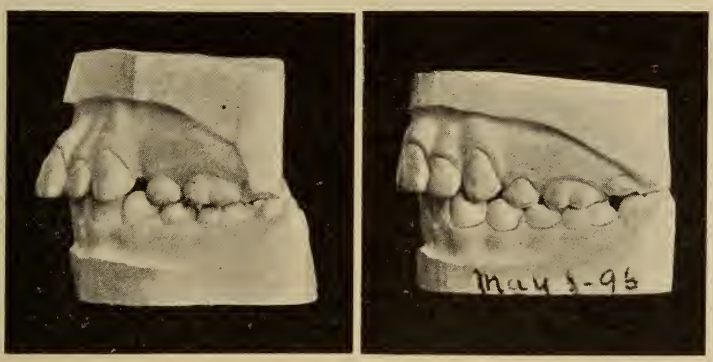


It is a noteworthy fact that a very little change in the peripheral shape or position of certain bones of the face on which the features are dependent for their character and form—a change so trifling that it could hardly be measured—resulting in a slight filling out or depression of

certain contours, will often beautify to a remarkable degree the appearance of a face that would otherwise be quite plain and unattractive.

This is true of all the more common cases of upper protrusion and retrusion which show an abnormal prominence or depression along the upper as well as the lower portion of the upper lip, and especially of those which seem to involve the entire incisive process, influencing the anteroposterior position of the wings and end of the nose.

FIG. 971



In cases of protrusion, by applying a retruding force especially directed to the roots and crowns of the anterior teeth, the surrounding alveolar process will be forced back, allowing the upper lip to fall into a more graceful and easy pose, leaving the nostrils less broad and open, the curve of the nose straightened, and its pug-like appearance removed.

FIG. 972



When an upper protrusion is due alone to a labial inclination of large crowded teeth, with no marked protrusion over the apical zone, or in segment 1, the extraction of the first or second bicuspids is indicated, and the application of force to the crowns at such points and in such direction as will best overcome the malposition.

Many instances have arisen, in the practice of dentists who were opposed to the extraction of teeth, when the above condition has actually been produced in the operation of crowding irregular teeth into alignment that were too large for an already perfectly harmonious maxillary arch (see Figs. 992 to 995 inclusive, in Section V).

Instances frequently arise in which the position and labial inclination of the upper anterior teeth produce a relative protrusion of the incisal zone and a contrusion of the apical, with a protrusion of the lower portion of the upper lip and a slight depression of the upper portion, deepening the naso-labial depressions (see Figs. 971 and 972). If the depression of segment 1 be not too pronounced, it may be restored by a slight forward movement of the anterior apical zone, accomplished in the retrusion of the incisal zone—by force applied at the incisal ends of the teeth alone, with the view of producing, as far as possible, a fulcrum force at the lingual margins of the alveola.

With marked cases of this character the protruded position of the uppers demands the extraction of the first or second bicuspids, and then if the roots of the labial teeth are decidedly retruded it will be found necessary to employ a contouring apparatus to move the roots forward while the crowns are retruded with the fulcrum bow of the same apparatus.

In contradistinction to this class of deformities, there is another quite as common—although not so frequently recognized as an abnormality—in which all the conditions are reversed, in that the teeth have a lingual inclination with protrusion of the apical zone and maxillæ.

The teeth of these cases are commonly regular in alignment, and owing to their lingual inclination the occlusal zone may be in proper relative position (Fig. 973).

The facial imperfection which consists principally in a prominence or bulging along the higher portions of the upper lip and in the region of the nasal alæ is often quite pronounced. When this is caused partly by the canine roots the difficulties are much increased in the case of patients older than thirteen years. The fact that the roots of the canines are surrounded by the most dense portion of the alveolar process, and their movement bodily in a posterior direction requiring the resorption of a large portion of bone, makes this operation one of the most difficult in dental orthopedia, even though the first premolars are extracted to permit the movement.

Fig. 973 is from the models of a patient over twenty years of age, and will serve to illustrate a case before and after treatment of abnormal protrusion of the roots of the upper anterior teeth, alveolar process, and maxillæ—the axis of the incisors being inclined lingually.

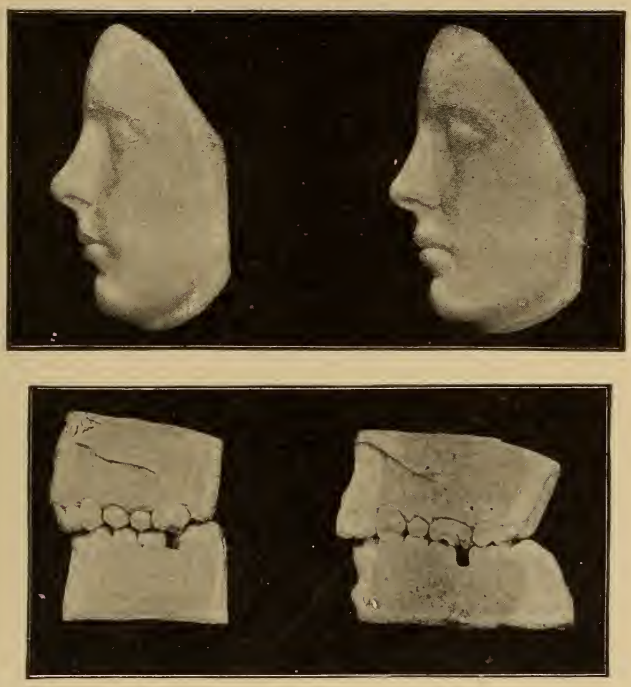
It will be observed that the canines have been moved bodily in a distal direction notwithstanding the advanced age of the patient.

If regulating appliances are properly constructed that will permit

the production of an independent static fulcrum at the occlusal ends of the teeth, so that the entire power of the machine may be directed and maintained upon the roots (see Figs. 1014 and 1015, in Section VI), perfect contrusion of the prominence will slowly but surely result.

If the teeth are crowded, overlapping, or turned on their axes, a correction of alignment may require the extraction of a bicuspid on each side in order to regulate them without an abnormal protrusion of their crowns. This is especially indicated when much retrusion of the canine roots is desired.

FIG. 973



UPPER DENTAL AND MAXILLARY RETRUSIONS

Facial imperfections which are due to insufficient fulness of contour in the central features of the physiognomy are quite common, and vary in degree from conditions that are hardly noticeable to those which may well be classed among the most unhappy of facial deformities.

There are several distinct types of this class of facial irregularity which are mainly due to an interruption in the development of the superior maxilla, although many arise from direct inheritance.

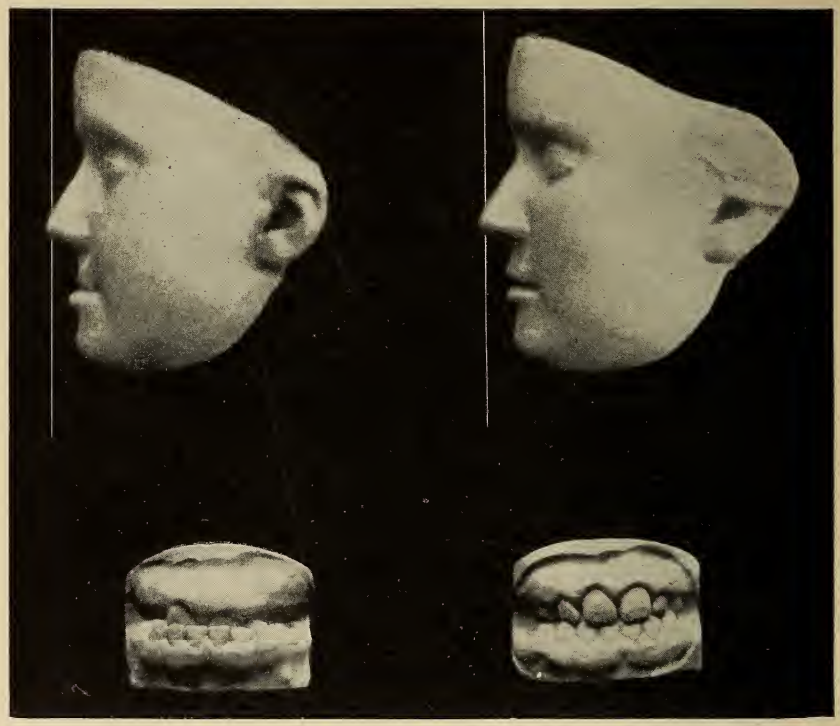
The primary cause of these conditions may be often very obscure and admit of nothing more tangible than conjecture, and, not unlike

many of the causes of irregular teeth, be really immaterial to the work of correction.

Retruded Upper Incisors and Intermaxillary Process.—In the more pronounced deformities of this class the physiognomy will often appear flattened, with prominent cheek bones and protruding chin and lower lip; the upper incisors occlude evenly with or posterior to the lower incisors, and at times are extensively inlocked in this position, as instanced by the case fully described and illustrated in Section I.

The upper incisors, which alone have their origin in the incisive process, are in their entirety posterior to a normal relative position. The labial inclination of the crowns, together with the deepened incisive fossæ, will show at once the contruded position of the roots and their maxillary surroundings.

Fig. 974



The upper lip resting upon the retruded teeth and the overlying process is proportionately depressed. Nor does the facial defect end here. The entire lower portion of the nose, supported as it is by the nasal cartilages which spring from the anterior nasal spine and lateral borders of the nasal orifice, is often decidedly affected in shape by the retruded position of its supports.

When there is a decided retrusion of the entire upper lip and lower

portion of the nose, with alæ resting in deep depressions caused by the unusual prominence of the naso-labial folds, the effect is that of an abnormal protrusion of surrounding parts, producing at times a startling expression of maturity that is only common to persons of advanced age. This expression can be seen in Fig. 974, which is that of a girl only twelve years of age, and will serve as a type of cases commonly met with in practice.

Fig. 975



Fig. 976



Retruded and Contracted Dental and Maxillary Arch.—In this class of deformities the physiognomy, in the more pronounced cases, has much the same characteristics as those described above, but presenting a more general retraction of the central features, with less pronounced naso-labial folds. The nose is often thin and the nostrils pinched; and although the end of the nose may be depressed, the distance from the tip to the more depressed lip is often lengthened. If the patient is a "mouth-breather" with the typical "open bite," the deformity and the difficulties attending its reduction will be greatly increased.

Fig. 977



Fig. 975 is from a profile model of a face of this class. Fig. 976 is from the same model photographed at a slightly different angle to show the angularity of the features.

Fig. 977 is a view of the teeth in natural occlusion. The lower first premolars have been removed preliminary to retruding the anterior teeth to reduce the abnormal protrusion of the lower lip and esthetically deepen the curve between the border of the lip and the chin. The figure has the appearance of a perfect occlusion of all the molars, whereas, on account of the very great narrowness of the upper jaw, the buccal

cusps of the second molars only, occluded with the lingual cusps of the lowers.

Fig. 978 shows palatal views of the upper arch before and after treatment.

Fig. 978



Fig. 979 is a view of teeth in natural occlusion after treatment. The entire upper dental arch, especially at the apical zone, was considerably enlarged. The "open bite" was partially closed by grinding the molars and partly by extruding the teeth anterior to the molars with small rubber bands extending from the upper to the lower teeth. Fig. 980 is from a model of the face after treatment.

Fig. 979



Fig. 980



As mentioned in Section II, a depression of the central features such as described is often mistaken for a prognathous jaw, and treated accordingly.

A slight retraction of the lower jaw will in nearly every case of this character produce an improvement in the facial aspect, because the chin and lower lip are brought into more perfect harmony with the depressed central features. Such a change, however, when it is not demanded, can never cause the beautifying effect produced by forcing the depressed

facial features—in segments 1 and 2—forward, thus bringing into perfect harmony the entire physiognomy.

Fig. 981



Fig. 982



This can be verified with any profile view of a typical case—as Fig. 981. Fig. 982 is the same face, except that the chin and lower lip have

Fig. 983

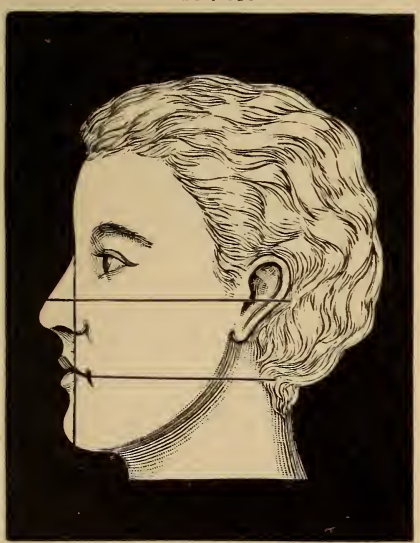


Fig. 984



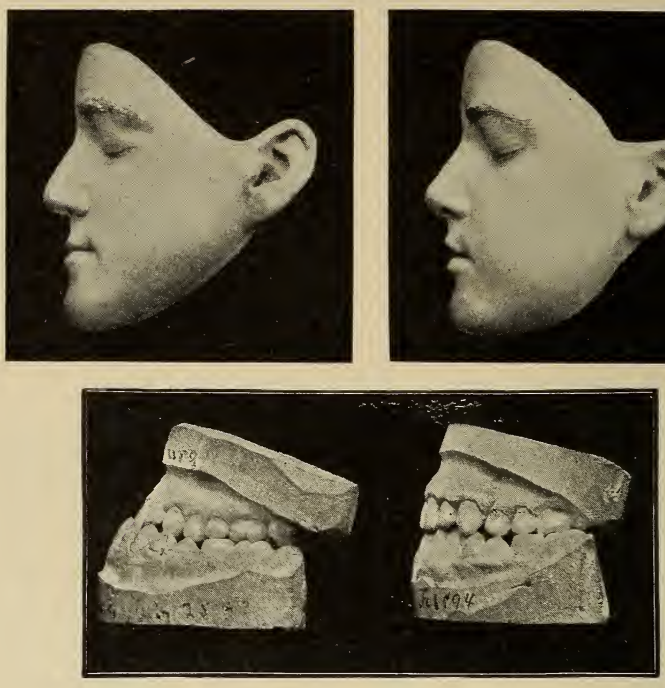
been retruded, producing a certain improvement, but not to be compared with Fig. 983, where the chin and lower lip retain the same relative

position to the unchangeable area as in Fig. 981, while segments 1 and 2 have been carried forward, with a result which proves (not alone in theory, but in practice) this to be the only true course to bring about an harmonious and esthetic adjustment of all the features of the physiognomy. Fig. 984 shows the actual difference, which may be verified upon trial, between Figs. 981 and 983.

Fig. 985 will serve to illustrate the common result in practical operations of this character.

The contouring apparatus (Fig. 1011) that is used to accomplish these results is fully described in Section VI. With it the apical zone of

Fig. 985



the anterior teeth may be enlarged and advanced to any desired degree; while the movement and inclination of the crowns are under the perfect control of the operator.

In this operation it will be found in a majority of cases, and especially with those which are begun as early as thirteen or fourteen years of age, that the entire incisive portion of the upper jaw may be carried bodily forward with the roots of the incisors.

The depressed features of the physiognomy—in segments 1 and 2 —that are dependent for their contour upon that portion of the maxillæ are thus brought into perfect harmony with other features of the face.

It is not here implied that there are not many cases of real prog-

nathous mandible in which its retraction, if possible, would produce a most desirable result; nor that such an operation is impossible if recognized and treated sufficiently early with properly adjusted apparatus persistently worn. The body of the mandible can certainly be forced back to a more posterior position in its relations to the upper, partly by bending the rami and necks of the condyles, and partly by absorption of the posterior wall of the glenoid fossæ.

The many failures that have attended these operations have been largely due to the advanced age of the patients and much to the fact that the apparatus is dependent upon the will or caprice of the patient for its persistent application.

On account of the early maturity and ossification of the mandible these operations should be undertaken as early as from five to ten years of age.

The caps fitted to the head and chin should be made to exert a uniform pressure over the surfaces upon which they rest, admit of free ventilation, and the whole apparatus when in place should have no projecting parts which will interfere with the comfort of the patient at night.

THE RELATIONS OF THE PHYSIOGNOMY TO THE SAVING AND EXTRACTION OF TEETH

In its widest scope this subject includes the propriety of saving, and on the other hand, the propriety of extracting certain teeth of the deciduous as well as the permanent dental arches which in any way influence the prevention, the production, or the correction of dento-facial irregularities. Two phases of this subject will be here presented. The first will be in regard to the saving or the extraction of the upper premolars for patients older than fourteen years, to correct a dental irregularity; the second will deal with the early extraction of the premolars to prevent an abnormal upper protrusion.

In the common form of dental irregularity shown by Fig. 986, especially if only the model of the upper jaw were the subject of study, it would in all probability be decided to extract the first premolars as the best course to pursue as a first step toward securing a perfect alignment of the dental arch; and the proceeding would be probably correct as far as the upper teeth alone were concerned. And again, if both upper and lower models were studied in occlusion and the irregularity of the lower arch was—as is usually the case—in correspondence with that of the upper, as shown in Fig. 987, the extraction of the lower first premolars would doubtless, and correctly, be decided upon. This plan of correction might even be decided upon after a superficial study of the face of the patient, which we may suppose to be similar to that shown in Fig. 988. Certainly the extraction of the lower first premolars which

have just begun to erupt, and the retraction of the anterior teeth would reduce the apparent protrusion of the lower lip and bring it into more perfect harmony with the depressed upper lip.

Yet when this face is carefully studied from the higher standpoint of esthetic development it becomes evident that the chin and lower lip are not protruded, in their relations to the malar prominences, the

Fig. 986



Fig. 987



bridge of the nose, and the forehead, but that the central features of the physiognomy are depressed even to a decided retraction of the lower portion of the nose; and that which is really demanded in this case is the advancement or forward movement of the entire intermaxillary portion of the jaw and incisor teeth; and further, every tooth in that dental arch is necessary for the ultimate retention of the several parts in their corrected position.

Fig. 988



Fig. 989



In the correction of malformations which demand the protrusion of the incisors bodily with the roots and intermaxillary process, the position of the canines, as in this case, will frequently prevent the proper attachment and application of apparatus for producing the desired effect; so that it often becomes necessary to first enlarge the dental arch and force the crowns into partial alignment by ordinary means, prepar-

atory to placing the incisors in the grasp of contouring forces. Fig. 989 shows the position of the teeth in this case in the intermediate stage, the crowns of the incisors being forced forward to a partial alignment, and with no special facial improvement. (It may be added that at this stage in the operation, cases of this kind have been considered finished, until it was found possible to enlarge the apical arch.)

Fig. 990

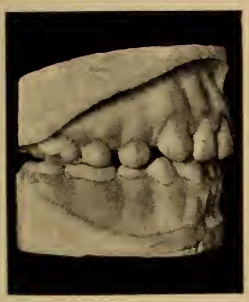


Fig. 991



Fig. 990 shows correctly the final result, which was accomplished with the contouring apparatus described in Section VI. It will be seen that the incisors are in an upright position and there is now ample room for all the teeth, while the remarkable improvement to the physiognomy is poorly shown by the face model Fig. 991.

Another case, that of the upper arch, Fig. 992, if examined alone and compared with the upper of the former case, or Fig. 986, will be

Fig. 992



Fig. 993



found very similar. The same crowded condition of the teeth, the same lack of sufficient room for the proper eruption of the canines; and yet this is from the model of a case that absolutely *demanded* the extraction of the premolars. At fourteen years of age the irregularity presented the appearance shown in the illustration Fig. 993, showing the models of the case in occlusion. The patient was placed in charge of a dentist

who attempted the correction of the irregularity without removal of the first bicuspids. Fig. 994 shows the result two years afterward.

It will be seen that the incisors were forced forward to a decided labial inclination, for the purpose of crowding the canines into alignment; and all the anterior teeth are turned on their axes so as to occupy the least possible space. Fig. 995 is from the model of the face of the patient at that time.

That a mistake was made in the plan of treatment pursued is evidenced by the following considerations: First, the protrusion of the crowns of the upper anterior teeth produces an unhappy expression of the mouth that is equivalent to a deformity, and one that could not be remedied in this particular until certain members of the dental arch were removed. Second, if it were a case in which the maxillary arch was too small, with a depression of the overlying features of the face, the decided labial inclination of the teeth could be overcome by an

Fig. 994



Fig. 995



enlargement of the apical zone, which would have permitted a slight retrusion of the occludal zone with a partial, if not complete, regulation of the dental and facial deformity. But this was not the condition, and therefore could not be considered. The third and most effective argument is one which should never be overlooked in all cases where the crowns flare outward. The conical shape of the teeth permits them to stand in perfect alignment, although with a decided labial inclination; but in this position the interproximate spaces so necessary to the preservation of the teeth are so completely closed as to cut off the union of interproximate gum tissue, which must ultimately result in the resorption of the gum and alveolar process and all the dire consequences that follow.

Had the first premolars been extracted, many difficulties in the regulation of the teeth would have been removed; and what is of far greater importance, there would have been a satisfactory result in the dental arch and physiognomy. Or even further, had the upper first premolars

been extracted as soon as they erupted, together with the deciduous canines, as will be outlined in the second phase of the subject, the case would have required little or no other treatment.

Fig. 996 shows the present position of teeth after regulation, by retruding the anterior teeth to fill spaces caused by the extraction of the

Fig. 996



Fig. 997



premolars. Fig. 997 is from a model of the face after treatment. It will be seen that the interproximal spaces between the teeth are restored, while the retrusion of the anterior teeth allows the lips to fall gracefully into proper position. The improvement in the facial aspect of this and all other cases cannot be fully shown by a plaster model of the face. Fig. 998 was made from a photograph of this patient, taken a few months after the completion of treatment.

Fig. 998



There are many instances where the early extraction of the premolars, as soon as they can be reached with the forceps, is demanded. For example, adult faces with decided protruding upper jaws and teeth, and with a bulged appearance about the lower portion of the nose. The teeth are commonly large, prominent, and crowded, although not always labially inclined.

The ordinary upper protrusions which come under this head are so common they will require no further explanation or illustration.

Upper protrusions where the teeth are not labially inclined are not quite so common. The alveolar arch is necessarily prominent, although the deformity in the main, as in the more common forms of protrusion, is due to the large size of the maxilla proper, which is far out of proportion to the delicately chiselled features which it supports and forces

into unsymmetrical contours. The naso-labial depressions in which the wings of the nose rest are more or less obliterated, as would be occasioned by the sting of a bee or an alveolar abscess. The nostrils are broad and open, and the end of the nose forced forward and upward (*retroussé*) by the protrusion of the spinous process and cartilaginous septum. The upper lip, being stretched over its inharmonious frame, is shortened so as to cover the teeth with difficulty, and in action readily rises to an unpleasant exposure of the teeth and gums.

This is an extreme, although not an uncommon, condition. Every stage from this to perfect harmony characterizes the innumerable varieties of a certain type of physiognomy.

Fig. 999 is from the face model of a young man, aged eighteen years, and may be taken as a type of this character of facial deformity. Fig. 1000 shows the teeth in occlusion. The canines and canine eminences are very prominent, and extend high up under the wings of the nose.

FIG. 999



FIG. 1000



Had this case received the early treatment here advocated the deformity would have been prevented, and the almost insurmountable difficulties attending its reduction during nearly three years of constant treatment altogether avoided.

Anyone who has never attempted to move the roots of the canines in a posterior direction for patients older than sixteen years cannot appreciate the difficulties of such an operation. And while the result in this case is quite satisfactory under the circumstances, as will be seen by Figs. 1001 and 1002, the physiognomy is not nearly so perfect esthetically as it would have been had the case received proper early treatment.

The important consideration from a surgical and artistic standpoint in nearly all cases of marked upper protrusion is: Has not nature been forced to produce these conditions, wholly or in part, to accommodate teeth that were too large for the natural or inherent frame and overlying features? And could we have helped nature in the early

years of development by making it unnecessary for her to produce this excessive growth of bone for the development and sustenance of all these large teeth?

This is true of all protrusions that are caused by the inheritance of inharmoniously large jaws crowded full of teeth.

We certainly cannot reduce the size of the teeth, but we can reduce their number, and in so doing reduce the size of the destined maxillary and dental arch. But we must make no mistake. The danger of advocating such a principle to those who have given this branch of dentistry little thought is that teeth may be extracted to accommodate an overcrowded condition in the arch, with little or no thought of the physiognomy, and too when a careful and properly pursued study of the features and their comparison with the parental types will show that in reality the dental and maxillary arch should be enlarged, and every tooth of the greatest importance in its development and retention.

Fig. 1001



Fig. 1002



How are we to study the undeveloped face of a child, every lineament of which is passing through rapid changes of growth, with a view of determining whether or not the dental arch and jaws will be too prominent, or that other features will not enlarge to a harmonizing proportion?

A most wonderful provision of nature in dentition causes the full-sized crowns of teeth to erupt, as regards time, somewhat in proportion to the natural growth and enlargement of the jaws. And even when they do not erupt earlier than is normal, or when their natural eruption is not interfered with by the premature extraction of the deciduous teeth, they are usually obliged to take an irregular position or attitude at first, and await the growth of the jaw which permits them to become regular.

It is perhape a safe general rule to never extract a permanent tooth for the purpose alone of correcting a dental irregularity, unless the jaw has ceased growing; and never then unless it is shown by a careful study

of the position of the teeth—their relation and occlusion—that the dental arch should not be expanded; or by a study of the physiognomy, that the alveolo-dental arch should not be enlarged?

In a study of the relations of the teeth, the jaws, and the physiognomy of a child with the view of determining the advisability of extraction to correct or prevent the ultimate production of a facial deformity or marked imperfection of the features, it may become necessary to study the physiognomies of both parents, and possibly other members of the family, to correctly determine the influence exerted by inheritance.

In this comparison of temperament, physical frame, features, and teeth, it may require no more than a glance to furnish all the data that will be of practical use.

Usually but one parent accompanies the little patient, and a study of that one physiognomy may be a sufficient guide; if not, other members of the family should be seen.

If there be a marked difference in the parents it may not be difficult to determine from which the child has inherited the teeth, by the peculiar shape and size of the incisors alone. But in regard to the maxillæ in an undeveloped condition there will be more difficulty, although it is well to remember that the deciduous teeth are rarely irregular or disproportionate in size to the frame and facial features. If, therefore, there be a more than natural difference in the size of the permanent and deciduous teeth it will indicate union of inharmonious types.

In this connection it must not be forgotten that the crowns of the permanent incisors are almost invariably far too large for their undeveloped surroundings. The apparently disproportionate size of the central incisors to that of the jaw is a subject of frequent and anxious parental comment. If the occlusion of the incisor teeth be far from a normal type in their anteroposterior relations, and the same condition exists with either parent, it is an indication of what the child will become if unaided by dental skill, especially if a similarity be noted in other particulars.

With differences in temperament, compare general shape and size of the eyes, brows, ears, and teeth.

Other features are so subject to change in the processes of natural growth and development that they cannot be relied upon to furnish legitimate data. For instance, the nose may change in a few years of late youthful development from one originally small and short—and over the nasal bones decidedly depressed—to a form different in every particular.

All these things are of the utmost importance in determining the impropriety of extracting certain teeth to reduce an apparent abnormal protrusion, which may in time become symmetrical in its relation by the natural growth of the jaws and other features; and also the equally culpable error of saving teeth, or the failure to extract teeth, whose

very presence in the arch obliges nature to reproduce a parental deformity, or produce an acquired deformity.

For a child with a marked upper protrusion similar to Figs. 1003 and 1004, with teeth prominent and crowded in an arch which does not admit of correcting by a lateral expansion, extract the first bicuspids as early as possible, even before their eruption is completed, together with the deciduous canines—unless it be one of those very rare instances where the first permanent molars cannot be saved.

The same is true of the lower, when there is reason to believe there will be a disproportionate overdevelopment of the lower dental arch.

In the ordinary course of eruption the development and eruption of the permanent canines are doubtless more influential than those of other teeth in emphasizing a protrusion of the central features of the physiognomy.

FIG. 1003



FIG. 1004



In the course of their eruption they are obliged to crowd into alignment along the mesial surfaces of the roots and crowns of the first bicuspids—which at this time represent the immovable bases of the arch—with the result that the incisive and intermaxillary portion of the arch is forced forward to a more pronounced position. This movement has been shown to be not impossible or difficult of attainment by artificial force, even much later in life.

With the first bicuspids and deciduous canines removed sufficiently early there are numberless instances when the arch, anterior to the second bicuspids, would be diminished the width of a bicuspid, without resort to artificial means.

By the exertion of a slight traction force from an occipital base of anchorage the sockets of the temporary canines will be closed by the permanent laterals, and the permanent canines in the course of their eruption will be deflected into the alveoli of the extracted bicuspids.

Figs. 1005 and 1006 represent one case out of many under treatment by this method, although not all by the occipital method, Fig. 1007 shows

the position of the teeth after about two months of traction force from molar anchorages; the protrusion not being so pronounced as to demand the use of the skull-cap.

It will be seen by the canine eminences—although far better shown upon the model itself—that the position of the canine crowns is imme-

Fig. 1005



Fig. 1006



diately over the former alveoli of the first bicuspids. As they continue to grow downward in this somewhat open channel, their roots, which are not at present developed, will grow upward, the teeth in their entirety finally taking a position and inclination similar to that of the bicuspids which they replace, and considerably posterior to that which they were otherwise destined to occupy.

Fig. 1007



The patient, aged nine years, had the teeth, eyes, ears, and general temperament of the father, whose upper arch was abnormally protruded in a similar manner, which was the *raison d'être* for dental aid.

Had the father's teeth been in proper relative and symmetrical position, and similar to the son's in other particulars which could be legitimately used as data, it would have been an argument in favor of

non-extraction with the expectation of other treatment later; but it should not have been passed upon without seeing the mother. Had the mother's teeth been found small and the general physical features cast in a more delicate mould than her husband's, investigations along other lines would have been required, with the view of determining if the child had not the large teeth of the father associated with facial bones that would always be inharmonious in size.

THE CONTOURING APPARATUS

The limited area upon which force can be applied to a tooth, compared with that portion covered by the gum and embedded in a bony socket, has made it next to impossible, with all ordinary methods, to move the apex of the root in the direction of the applied force; nor could this ever be accomplished with force exerted in the usual way at one point upon the crown, however near the margin of the gum it may be applied, for the opposing margin of the alveolar socket must receive the greater portion of this direct force, and in proportion to its resistance it will become a fulcrum exerting a tendency to move the apex of the root in the opposite direction.

Fig. 1008

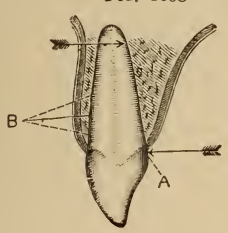
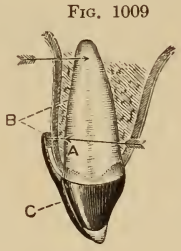


Fig. 1009

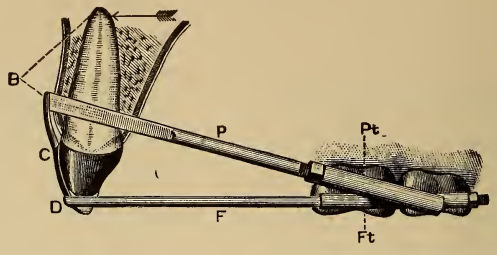


But if in the construction of the apparatus a static fulcrum is created independent of the alveolar process at a point near the occluding portion of the crown, while the power is applied at a point as far upon the root as the mechanical and other opportunities of the case will permit, the apparatus becomes a lever of the third kind, the power being directed to a movement of the entire root in the direction of the applied force.

This proposition is made plain by reference to diagrams. In Fig. 1008 let *A* be a point upon a central incisor at which force is applied in the direction indicated by the arrow, then the opposing wall, *B*, of the alveolar socket near its margin will receive nearly all of the direct force; and in proportion to its resistance there will be a tendency to move the root in the opposite direction. This will also hold good even if the force be applied at *A*, Fig. 1009, or as far upon the root as may be permitted by attaching a rigid upright bar, *C*, to the anterior surface of the

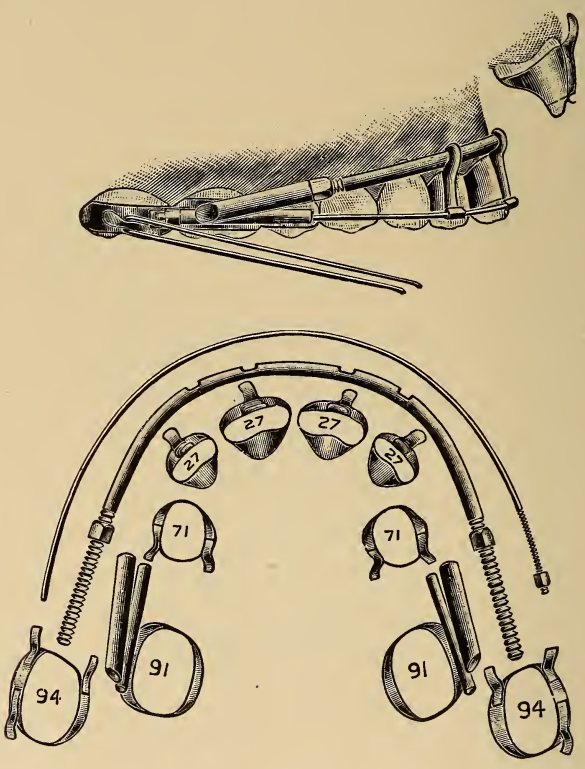
crown; the only difference being that the direct force is distributed over a greater area. But if, as in Fig. 1010, to the lower end of *C* a traction wire or bar, *F*, is attached, and if the mechanical principles of

Fig. 1010



the machine be further enforced by uniting its posterior attachment to the anchorage of the power bar *P*, the anchorage force will be materially

Fig. 1011



neutralized and an independent static fulcrum at *D* created. The apparatus now will distribute its force over the entire root, and give complete direction and control of whatever power is put into it. The

entire tooth may be carried forward bodily or either end may be made to move the more rapidly. The force thus directed to the ends of the roots will have an increased tendency to move the more or less yielding bone in which they are embedded.

For practical illustrations of what has been accomplished by an apparatus of this kind in moving the upper labial teeth forward bodily, see cases described in Sections I, IV, and V.

As nearly all irregularities of this class demand a protruding movement of the upper labial teeth, with the view of carrying forward with the roots the labial alveolar ridge and incisive process, it is of the greatest importance that every detail in the modern construction and application of the only apparatus calculated to effectively perform this work should be fully understood, as upon this will largely depend the real success of the operation.

The drawing represents the regular protruding contour apparatus, adapted for all pronounced cases of this class in which a considerable bodily protruding movement of the upper labial teeth is demanded. The scientific principles of movement accomplished by this apparatus have been fully explained. In this apparatus the power bow is No. 13 extra hard German silver. The rootwise bar attachments on the incisor bands are also cut from the same size of wire, and are formed to receive the force of the bow above the gingival borders.[1]

Provision should always be made for the attachment of the intermaxillary elastics at the distal extremities of the anchorages. If the second molars have erupted, these teeth should be joined to the anchorages for the attachment of the buccal hooks as shown. Otherwise, the elastic bands are looped over the distal ends of the fulcrum tubes.

The teeth should be properly separated, and each finished band and anchorage so perfectly fitted that it can be easily forced on and off with the aid of a wood plugger and band removing pliers,[2] to make slight but necessary changes in the shape or position of the attachments or power bow. The power bows for extensive movements are always No. 13 extra hard. They should be bent, first upon the model and finally at the chair, to conform to the shape of the arch, and their ends to lie evenly in the power tubes without the slightest tension. In the final moves of this important requirement, place the anchorages in position and the power bow with the threaded ends lying along the outside of the tubes. Then place the right end in its tube and see that the other lies exactly parallel with the left tube and in proper shape and position in front. Then place the left end in its tube with the other end free, and go through the same movements.

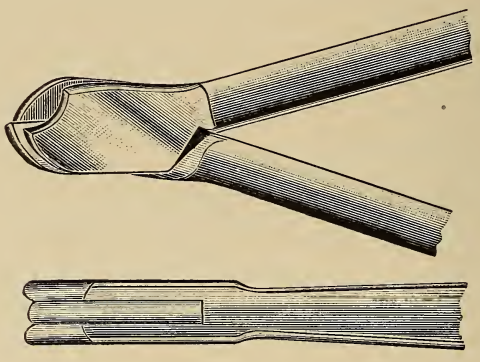
[1] For the construction of the anchorages, see Stationary Anchorages, Chapter VII, Dental Orthopedia, and then turn to B. 91 for directions in placing and soldering the fulcrum and power tubes.

[2] Ibid.

This may require repeating several times, with the greatest nicety of judgment and patience in detail, before you are able to assemble the bow and anchorages properly together. The heavy bending pliers, Fig. 1012, are indispensable for this operation.

In assembling the power bow with the anchorages, after it has been properly shaped, insert one end in its tube with the anchorage in place, then slip the tube of the other anchorage on to the free end of the bow and force it to place on the teeth. These movements should be observed in the final cementing of the anchorages, as it would be impossible to place the rigid bar otherwise. In the preliminary assembling after the anchorages and bow are properly placed, the labial bands which have been previously fitted to the teeth are placed in position, with their rootwise extensions resting over the bow. It may be found at this time that the bow will require lifting or lowering slightly by bending it at the sides while in position, to bring it to the exact position to be clasped

Fig. 1012



by the extensions. The latter will also usually require bending and filing to fit them to the requirements of the bow. The ends are filed on the gingival side to a flattened taper, which should extend a trifle beyond the bow with a slight lingual curve, to aid them in retaining their position under tension.

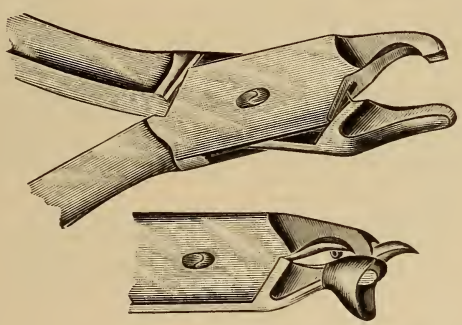
In the shaping and fitting of the rootwise attachment and bow, the greatest care and consideration should be exercised. First, the bands for extensive movements should extend nearly to the highest gingival border of the gum, and from that point the rootwise extensions should bend forward so as to freely clear the borders of the gum, and then back to a position to slightly overlap the power bow.

The difficulty of bending the rigid extensions to a sharp angle, if necessary, without injury to their band attachments, may be overcome by using the special pliers shown in Fig. 1013, which is made to clasp the band and its attachment firmly, while the extension is given the desired shape with pliers and file. Second, the power bow should rest slightly

above the highest marginal points of the central incisors and, in the final fitting, conform to the shape of the gum, but freely clear its surfaces. This is very important as the natural swelling of the gums in the operative action will be greatly increased by any undue pressure of the bow. Should this be found to be a fact at any time during the operation the labial bands should be removed, and the extensions, upon which the relative position of the bow to the gum depends, should be bent forward so as to free the bow from its embedment in the swollen gum. Third, in the original shaping of an upper power bow it will be usually advisable to curve it downward at the median point to prevent it from interfering with the free action of the frenum.

Before removing the temporarily assembled apparatus, the bow should be marked on each side of the respective rootwise extensions, for guide markings to cut the square grooves, shown by the drawing, in which the extensions rest while in action. In the final cementing of

FIG. 1013



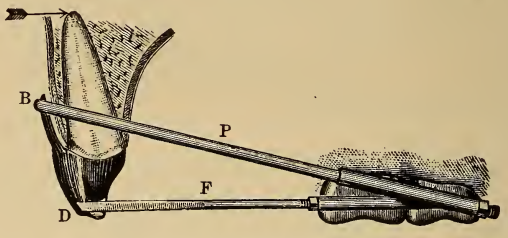
the labial bands, they are simply carried to their respective positions on the teeth and bow. The fitting and placing of the fulcrum bow No. 22 is the same as for the small alignment bows which are threaded at one end.

Treatment Adjustments.—In applying the force which is to follow the first conscious tension of the nuts, the large nuts of the power bow should be given about two quarter turns three times a week. As the movement advances it will become necessary to unscrew the fulcrum nut occasionally to allow the incisal zone to move forward with the roots. If the roots are found to be moving dangerously fast for the safety of their vitality, the application of force should be stopped in the power bow, and if necessary the nuts may be unscrewed slightly. Unscrewing the nut upon the fulcrum bow is also equivalent to reducing the force upon the roots. It may be advisable to cut and remove the fulcrum bow entirely, to be replaced with a new one when the danger is past. The danger line will

be indicated by unusual sensitiveness to heat and cold over the root or roots of the affected teeth, which should not be allowed to arrive to a continual pain. Perfect rest should be afforded to the teeth and the gum painted with strong tincture of iodin, two or three times a week, until all irritation subsides.

Those who have followed closely the directions will realize something of the difficulties and skill necessary for the perfect accomplishment of bodily moving the labial teeth for the correction of facial contours. The author wishes to say that unless the operation is considered of sufficient importance to give to it the same painstaking skill that is demanded in other branches of dentistry, it had better not be attempted, as in all probability it will prove a failure. This refers not alone to the construction and application of the regulating apparatus, but to the construction and attachment of the proper retaining appliance that is intended to permanently sustain the position gained. On the other hand the truly wonderful work which this single apparatus has accomplished in the author's hands, attested now by hundreds of cases, proves to him that its work in other hands will cause this principle to live and grow in favor.

FIG. 1014



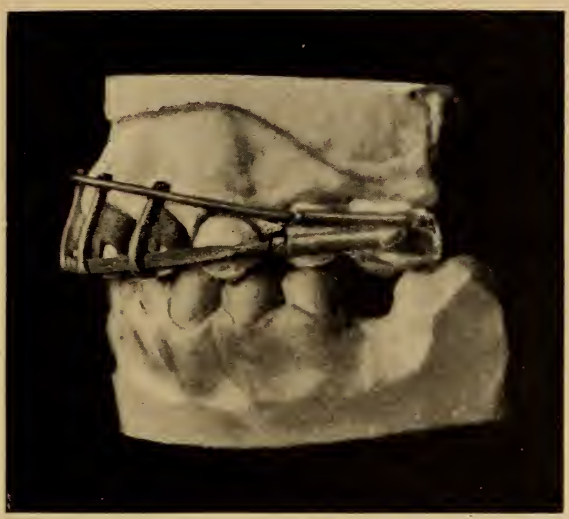
An apparatus for retruding the roots of the anterior teeth is constructed in a very similar manner (Fig. 1014). The direction of the two forces being reversed, it becomes necessary, however, to make certain important variations. The power bow *P*, now exerting a traction force, No. 16 will be found sufficiently large for all purposes. It is not flattened, but rests in grooves cut in the anterior surfaces of the upright bars *B*. The power-bow tubes should be soldered closely to the anchorage bands, so that the nuts which now work at the posterior ends of the bow will not irritate the mucous membrane of the cheek. The fulcrum bow *F*, exerting in this apparatus a jack-screw force, should also be No. 16. It is flattened along its middle portion to engage with the occluding ends of the upright bars at *D*, provision being made for the purpose in the construction.

The power of the two forces being so great upon the upright bars, with a tendency to lift the occluding ends from their attachments, and thus allow the free ends to press into the gum, it is important with this

apparatus that the occluding end attachments be reinforced by soldering to the bands an extra piece of banding material that shall extend from the labial face over the occluding end of the tooth to the lingual portion (Fig. 1015).

After the joint of the band has been soldered, the reinforcing piece, of sufficient length for the purpose, should be soldered to the labial

Fig. 1015



face alongside of the joint; then the band is perfectly fitted to the natural tooth—the extra piece being bent over and burnished to its position on the labial surface, and the position of its end distinctly marked upon the band, to serve as a guide to soldering.

When the hoods are completed in this way and finally all placed on the tooth and perfectly fitted, an impression should be taken for fitting and soldering the upright bars as described for the protrusion apparatus.

CHAPTER XXIII

ORAL PROPHYLAXIS

By S. H. GUILFORD, A.M., D.D.S., Ph.D.

When it is remembered that the mouth is the principal vestibule leading to the internal organs; that through it must pass all of the aliment designed to promote and sustain bodily function; that into it the various salivary glands pour their secretions, which become mingled with the food and then pass on to take part in the process of digestion, it becomes apparent that this important cavity should at all times be kept in a thoroughly pure and healthy condition in order that what passes through it may not be contaminated.

All saliva carries with it in solution an amount of calcium salts which may attach itself to the tooth surfaces and afford a favorable opportunity for the lodgement and retention of minute food particles, which, if allowed to remain, undergo putrefactive decomposition, causing serious injury to tooth substance.

In addition, the deposit furnishes a habitat for various forms of bacteria, which, passing into the stomach, may interfere with the process of digestion, or their toxins may produce pathological conditions which will, to a greater or less degree, affect the health of the individual.

Oral prophylaxis is that branch of dental science which has for its object the maintenance of a clean and healthy condition of the oral cavity. This can be brought about only by the skilful and conscientious service of the dental practitioner conjoined with the utmost care and diligent coöperation on the part of the patient.

While it has long been known that caries of the teeth could be greatly minimized and largely prevented by the careful and frequent removal of foreign deposits and accumulations from and between the teeth, it is only recently that the profession and the laity have awakened to the fact that the oral cavity could be so carefully kept as always to be in a healthy condition, and that when in this condition many ills hitherto unaccounted for would be prevented.

Once the dental practitioner felt that his duty was performed when he had removed the most visible deposits found upon the teeth whenever the patient happened to present for other service, adding, perhaps, a word of advice as to the more frequent use of brush and powder. No effort was made to impress upon the patient the value of this personal care other than that it would measurably prevent future caries, neither

was he urged to present himself at frequent and fixed intervals for inspection and professional assistance in the way of prophylactic treatment.

Now, in the light of fuller knowledge, the practitioner has come to regard himself as the custodian of the patient's mouth, and feels it to be part of his professional duty to fully explain the importance of oral hygiene and emphasize the necessity for constant watchfulness and care if the dental organs are to be preserved for a lengthened term of years and the general system measurably protected from the disturbing influence of pathogenic organisms.

When the patient has once been fully impressed with the necessity for unremitting care on his part, and the importance of periodic visits to the dentist, the foundation will have been laid for the best results that oral prophylaxis can accomplish.

In beginning the treatment for a patient, the first requirement is that the teeth be carefully examined, and then by proper instrumentation freed from all hard deposits found upon any of the exposed surfaces of the crowns and also from the lesser deposits that often lie beneath and are concealed by the free margin of the gum.

So carefully should this part of the operation be performed, that when completed no calcareous matter may remain anywhere upon the teeth. Next, the labial, lingual, and buccal surfaces should be gone over and further cleaned with orange-wood stick and pumice, rigorously applied. This will not only remove any minute portions of ordinary foreign matter, but also such gelatinous plaques or accumulations of inspissated mucus as are most generally present. After this the stick and pumice should be used upon such portions of the approximal surface as can be reached by them, and finally floss silk, charged with pumice, should be passed to and fro between the teeth to cleanse and polish thoroughly the surfaces most nearly in contact. In this manner every part of each tooth surface will receive thorough treatment.

The pumice used should be of the fine variety known as pumice flour, and if incorporated into a pasty mass with glycerin it will adhere better to the stick and floss and render more efficient service.

This cleansing of the teeth cannot be done thoroughly if done hastily. The operation must be carried forward with a fair amount of deliberation, so that no single feature of it may be overlooked. If the case in hand is one that bears evidence of long neglect, two or three hours' time may have to be spent upon it in order to bring about a proper condition of cleanliness. In many cases it will be well to divide the operation between several sittings in order to avoid undue nerve-strain or suffering on the part of the patient.

When once completed the patient should be given to understand that this first operation, while placing the mouth in a hygienic condition, is but the beginning of the treatment. and that it will have to be followed

up by successive treatments of a similar but much milder character at intervals of a month or two; the frequency of the treatments depends largely upon the faithfulness of the patient in his personal care of the teeth during the intervals.

As to the patient's part in furthering the prophylactic treatment, he should be instructed to brush his teeth carefully immediately upon arising, after each meal, and again before retiring. At least once a day, at one of the brushings, a dentifrice should be used to supply the necessary friction which the brush alone would not provide. Dental floss must also be passed between all of the teeth after they have been brushed, and at any intermediate times when food has been taken.

It should be made plain that all the details of treatment must be conscientiously carried out both by patient and operator if success is looked for, and the patient may be assured that by faithfully complying with the regulations laid down not only will his mouth be kept in a thoroughly hygienic condition and decay of the teeth controlled, but that recession of the gums and inflammation and destruction of the subjacent tissues about the roots of the teeth will be largely and often entirely prevented.

One of the main contributing causes to success in oral prophylaxis lies in awakening in the patient's mind the necessity for the elaborate and persistent treatment proposed.

As prophylaxis of the oral cavity is still a novel idea to the laity, and they are likely to confound it with the old and simple operation of cleaning or cleansing the teeth, patients may fail to realize the necessity for the many visits to the office and the increased cost of the frequent treatments.

For this reason it is necessary for the operator, if he wishes to achieve the best results of treatment, constantly to hold before the patient the advantages that are sure to accrue from faithful and continued treatment and the dire results that are certain to result either from neglect or interrupted service.

Unless the interest of the patient is aroused to the extent of making him a convert to the gospel of mouth cleanliness, coupled with the fear of early loss of the teeth when treatment is neglected, we can hardly hope for success in our efforts.

A patient must either be won over to our views in the beginning or he will discontinue the treatment after a few visits and fail to realize the intended benefit. Patients afflicted with pyorrhea and its accompaniments of pain and loosening of the teeth are usually very willing to undergo a course of prophylactic treatment in the hope of obtaining relief; but those whose dental organs and oral tissues have given them no perceptible trouble are not so easily converted to the importance of prophylaxis as a preventive measure.

The advantages to be derived from systematic prophylactic treatment

may be summarized and presented to patients in some such form as the following;

1. The oral cavity will be kept in a thoroughly clean and sanitary condition.

2. The breath will be free from offensive odors.

3. Dental caries will be largely prevented by the removal of those active agents which are mostly responsible for it.

4. Extensive caries cannot occur because the frequent examinations will disclose the very beginnings of tooth injury.

5. Gum recession and root exposure will be delayed or prevented by the sanitary condition prevailing and by the gentle stimulation of the gum tissue induced by the frictional treatment.

6. In like manner the irritation caused by calcareous deposits at or beneath the gum which promote, if they do not really produce, pyorrhea will be eliminated.

7. By preventing gum irritation and controlling pyorrheal tendencies the teeth should remain firm and useful to advanced age.

8. With the oral cavity kept relatively free from pathogenic organisms, and foreign substances undergoing putrefactive decomposition, the digestive functions will be less likely to be unfavorably influenced, and the entire system will be better in consequence.

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